environmental inventory

A HISTORICAL SUMMATION OF ENVIRONMENTAL INCIDENTS AFFECTING SOILS AT OR NEAR THE U.S.AEC ROCKY FLATS PLANT.

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I. INTRODUCTION

On September 21 and October 2, 1973, B. W. Colston, Area Manager, Rocky Flats Area Office, U. S. Atomic Energy Commission, requested information concerning contaminated materials and waste storage tanks. On October 4, 1973, the request was broadened to include the development of a comprehensive plan of action dealing with the investigation and unqualified location of all contaminated soil on the Rocky Flats plant site. The plan was to include but not necessarily be limited to defining locations, quantities of soil involved, and preparation of cost estimates and schedules for proper disposal.

The preliminary response to these requests, which was intended for use in briefings, was submitted on October 30, 1973, and included:

1. A color-coded map showing where waste lines exist and what type of materials are transported in the lines. Footing drains, foundation drains, and the general flow of surface runoff were included.

2. A discussion of instances wherein significant quantities of radioactive or other toxic liquids are stored in tanks and the means available to detect leakage and initiate corrective actions if required.

3. A color-coded map indicating burial sites with the type and estimated quantity of material buried. This map indicated locations where significant amounts of contaminated materials were deliberately buried or contained and did not include areas known or suspected to be contaminated due to weather actions, spills, leaking pipelines, etc.

4. A list by type and quantity of all harmful or potentially harmful materials currently being used on plant site.

The following is the expanded and detailed information which was requested and is the result of searching records, reviewing literature, and

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numerous discussions with a large number of employees many of whom have been employed at Rocky Flats since 1952.

In describing the location and types of materials involved, the use of the word "contaminated" has been purposely avoided. This is not to be interpreted as an attempt to avoid the issue but merely to emphasize that no official definition of "contaminated" exists. Section III is devoted to a detailed discussion of "contaminated."

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II. INFILTRATED SOIL INVENTORY

Soils under and around Buildings 559, 701, 770, 771, 774, 776-777, 779, and 995 have become infiltrated with various radioactive and chemical materials as a consequence of long-term, routine operations. Foundations, footings, pilings, and associated drainages must be considered both radioactively and chemically infiltrated by leaks, spills, weather actions, etc. The principal radioactive material in these areas is plutonium with minor amounts of other radioisotopes and plutonium decay products (^{241}Am). Estimated activity levels range from below present detection levels to greater than 10^6 dpm/100 cm^2, actual levels are in all probability far less than the maximum. Major chemicals involved include nitrates, chromates (Cr^{+6}), organics (such as CCl_4), and, in some locations, beryllium.

Soils under Building 707, while faced with the same potential for structural infiltration of radioisotopes and chemicals, are not at this time considered operationally affected to the extent noted for other structures.

Soils under and around Buildings 441, 442, 444, 447, 865, 881, 883, 886*, and 889 are also infiltrated. Soils under Buildings 122, 123, 125, 439, and 440 are involved but to a lesser degree. With the exception of possible extremely low levels of plutonium under and around Buildings 122, 123, and 881 and minor ^{233}U in Building 881, the major radioisotopes of concern in these areas are enriched and depleted uranium. Chemically, nitrates, chromates, and beryllium infiltration are to be expected, especially in the "400" Complex and under and around Building 865 and 881.

Some uranium infiltration may exist under Buildings 331, 884, and 991, but levels are low, possibly undetectable.

*While plutonium is handled in Building 886, it is handled in solid form only. Enriched uranium spills are considered as the only major possible contributions.

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A summary of the relative degree of soil infiltration under buildings known or suspected to be radioactively or chemically infiltrated at Rocky Flats is shown on Table I.

Details of each building and the surrounding area are included with the following maps.

TABLE I

The following buildings at Rocky Flats are currently known or suspected to be radioactively or chemically infiltrated. It is assumed that the soil under each building is similarly infiltrated.

Building	*Type Of Radioactive Infiltration	**Estimated Degree Radioactive Infiltration	Chemical Infiltration
122	Pu	Trace	Trace
123	Pu	Low	Moderate
125	Pu	Trace	Trace
331	EU	Trace	
334	EU	Trace	
439	DU	Trace	
440	DU	Trace	
441	DU	Trace	Moderate
442	DU	Low	Trace
444	DU	Low	Moderate
447	DU	Low	Low
559	Pu	Moderate	High
663	Pu	Trace	Trace
701	Pu	Low	Trace
707	Pu	Low	Trace
770	Pu	Low	Low
771	Pu	High	High
774	Pu	Moderate	Moderate
776	Pu	High	Low
777	Pu	Moderate	Low
778	Pu	Low	Low
779	Pu	Low	Moderate
865	DU	Low	Low
881	EU	Low	High
883	EU	Low	Trace
884	EU	Trace	
886	Pu	Trace	Trace
889	EU	Low	Moderate
991	Pu	Trace	

*Type of radioactive infiltration refers only to major radioactive material involved. Other radioactive elements are also involved but to lesser extent.

**Degree of infiltration refers to relative cost of cleanup.

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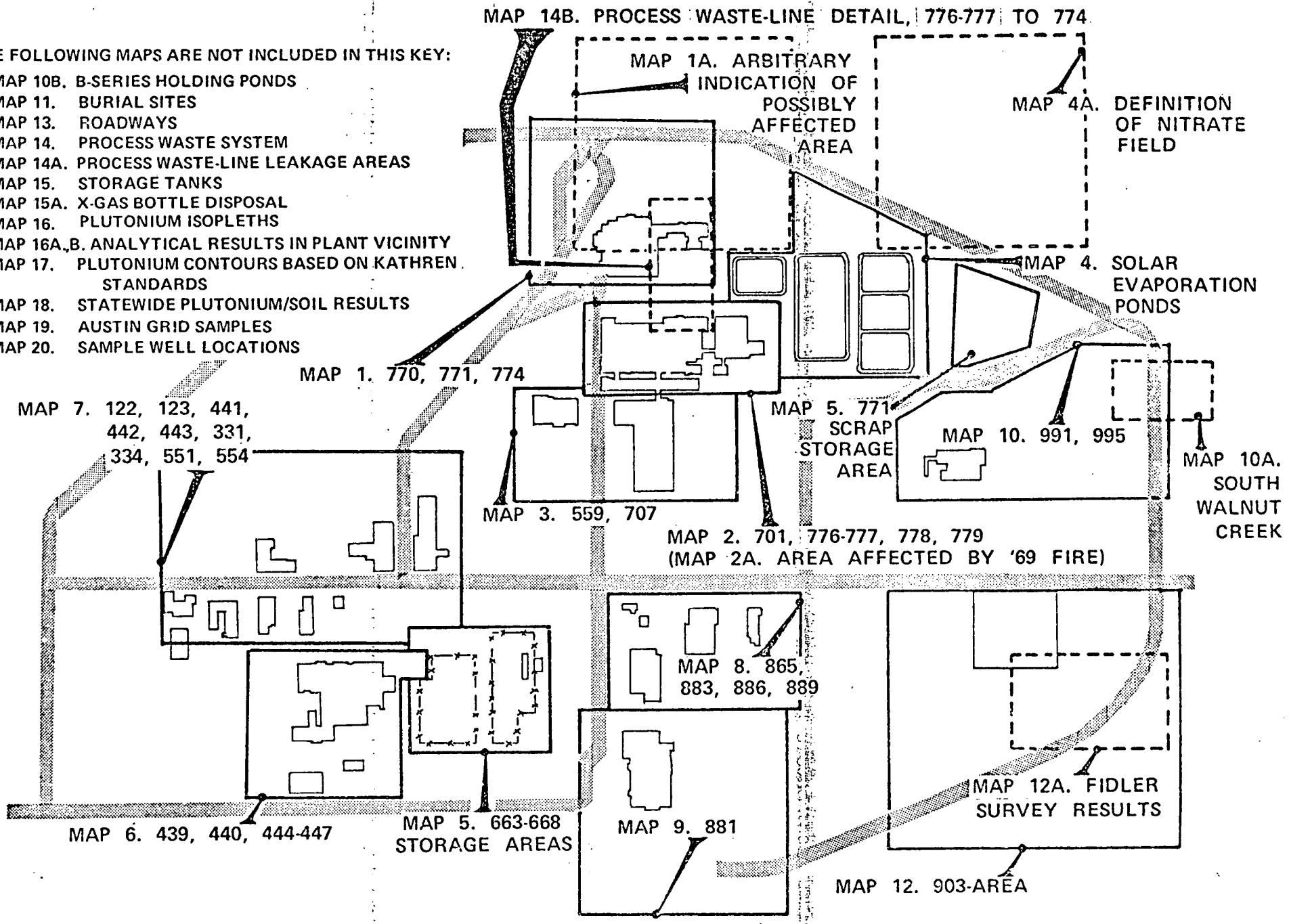
THE FOLLOWING MAPS ARE NOT INCLUDED IN THIS KEY:

- MAP 10B. B-SERIES HOLDING PONDS
- MAP 11. BURIAL SITES
- MAP 13. ROADWAYS
- MAP 14. PROCESS WASTE SYSTEM
- MAP 14A. PROCESS WASTE-LINE LEAKAGE AREAS
- MAP 15. STORAGE TANKS
- MAP 15A. X-GAS BOTTLE DISPOSAL
- MAP 16. PLUTONIUM ISOPLETHS
- MAP 16A,B. ANALYTICAL RESULTS IN PLANT VICINITY
- MAP 17. PLUTONIUM CONTOURS BASED ON KATHREN STANDARDS
- MAP 18. STATEWIDE PLUTONIUM/SOIL RESULTS
- MAP 19. AUSTIN GRID SAMPLES
- MAP 20. SAMPLE WELL LOCATIONS



KEY TO SECTIONAL MAPS

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Incidents by Area

Map 1 (Buildings 770, 771, and 774)

The nature of operations in Buildings 770 (Scrap Storage), 771 (Chemical Recovery), and 774 (Liquid Waste Treatment) are such that infiltration is inevitable. Remarkably, there have been relatively few incidents which have, as a rule, been quickly contained and cleaned. A summary of some of the major incidents follows.

Physical default of process waste storage tanks and drums has been one of the major contributors of chemical and radioactive materials to the soil around these buildings. Leaking process waste tanks in 1957 (south of Building 774) contributed levels of up to 2,500 dpm/g (gross alpha) and leaking drums (north of Building 771) in 1971 contributed levels up to 100,000 dpm/100 cm^2 on asphalt. Both the soil and asphalt (about 200 square feet of asphalt in one incident and about 2,300 in another) were removed for off-site disposal.

As noted on Map 1, the outfall northwest of Building 773 has been the site of some material accumulation. This outfall resulted from the release of plutonium in laundry water and water from laboratory sinks. In 1958, radioactivity of 17,400 dpm/g was detected in the soil at this outfall. Soil samples collected in 1971 indicated 100,000 dpm/g. The plumbing leading to this outfall was corrected and 149 drums of soil were removed for off-site disposal.

The area immediately adjacent to the Building 771 ventilation stack must also be considered an area of interest, however, fallout from this stack is minor compared to process waste infiltration (discussed in conjunction with Map 14). The underground plenum leading to the stack is also of interest.

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Chemically, there have been several instances of caustic and acid spills in this area. Hydrofluoric acid (HF) has, on occasion, infiltrated the soil around the HF storage shed, but due to the extreme reactivity of this material, little or no environmental-affective residue would be expected. The potassium hydroxide (KOH) and sodium hydroxide (NaOH) tanks south of Building 771 and north of Building 774, respectively, have also overflowed, leaked, etc. In all cases, these spills have been dramatically diluted with water and, with one possible exception, should have limited environmental consequences. That possible exception would be an overfill in the KOH tanks south of Building 771. It is likely that much of the overflow penetrated soil to the level of the Building 771 foundation and infiltrated soil under the building. However, the presence of springs and subsurface runoff under the building have more than likely reduced the possible concentration to an inconsequential level.

Table II documents major incidents in the Buildings 770-771-774 area.

It should be noted that while corrective action has historically been to remove the affected soils, it is a physical impossibility to remove it all. Therefore, "minor" infiltration inevitably remains and relative "hot spots" are to be expected, even if not detected.

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TABLE II

Major Incidents in the Area of Buildings 770, 771, and 774 (See Map 1)

(Note: Pipeline leaks, etc., are discussed separately.)

Prior to 1956, the process waste holding tank located north of Building 771 overflowed on several occasions with minor impact.

1956 October: Process waste tanks (Building 774) overflowed, minor environmental infiltration.

1957 August: Leaking process waste tanks (Building 774), minor environmental infiltration cleaned up.

September: Building 771 fire - some environmental infiltration, particularly north and near the hatch on the southwest corner of the building. Actual levels unknown, soil and vegetation samples inconclusive.

1958 April: Soil infiltration noted at laundry outfall (Building 773), 17,400 dpm/g.

1963 January: Liquid containing plutonium spilled outside Building 774 entrance. Material cleaned up.

1964 January: Coveralls containing plutonium found on west dock of Building 771. Levels to 100,000 dpm/100 cm^2 found on dock and in locker room. Cleaned up immediately.

1968 May: Sewer line break at Building 771 resulted in sewage lift station tank overflow to Building 773 outfall. Low concentration of radioactive and chemical materials.

1970 **May:** Soil samples collected from Building 773 outfall; approximately 100,000 dpm/g. Plumbing modified in September 1970 and 149 drums of soil removed for off-site disposal. (Removal completed August 30, 1971.)

1971 Scrap drum leakage (June and July) resulted in recorded levels to 300,000 dpm/100 cm^2 on about 2,500 square feet of asphalt north of Building 771. Asphalt removed for off-site disposal. In September, construction excavation between Buildings 771 and 774 exposed tunnel which contains process waste line and which at one time was used as an exhaust ventilation duct for Building 774. The exposed cracks in the tunnel were sealed. Eight drums of soil (approximately 24 dpm/g) were removed for off-site disposal in January, 1972.

September: Building 774 dock - unknown source resulted in estimated levels to 200,000 dpm/100 cm^2. Thirty-six drums of soil removed for off-site disposal.

1972 **March:** Approximately 500 gallons of plutonium waste (approximately 350,000 dpm/liter) inadvertently released from Building 774. Pond samples showed only slight increase in activity. Started removing soil around Building 774 waste tanks for installation of new inspectable processing tanks.

August: A punctured scrap box and drum resulted in up to 200,000 dpm/100 cm^2 on approximately 3,600 feet inside and approximately 500 square feet outside Building 770. Cleanup began immediately, soil and asphalt removed for off-site disposal.

1973 There were no incidents which were considered to have resulted in environmental infiltration.

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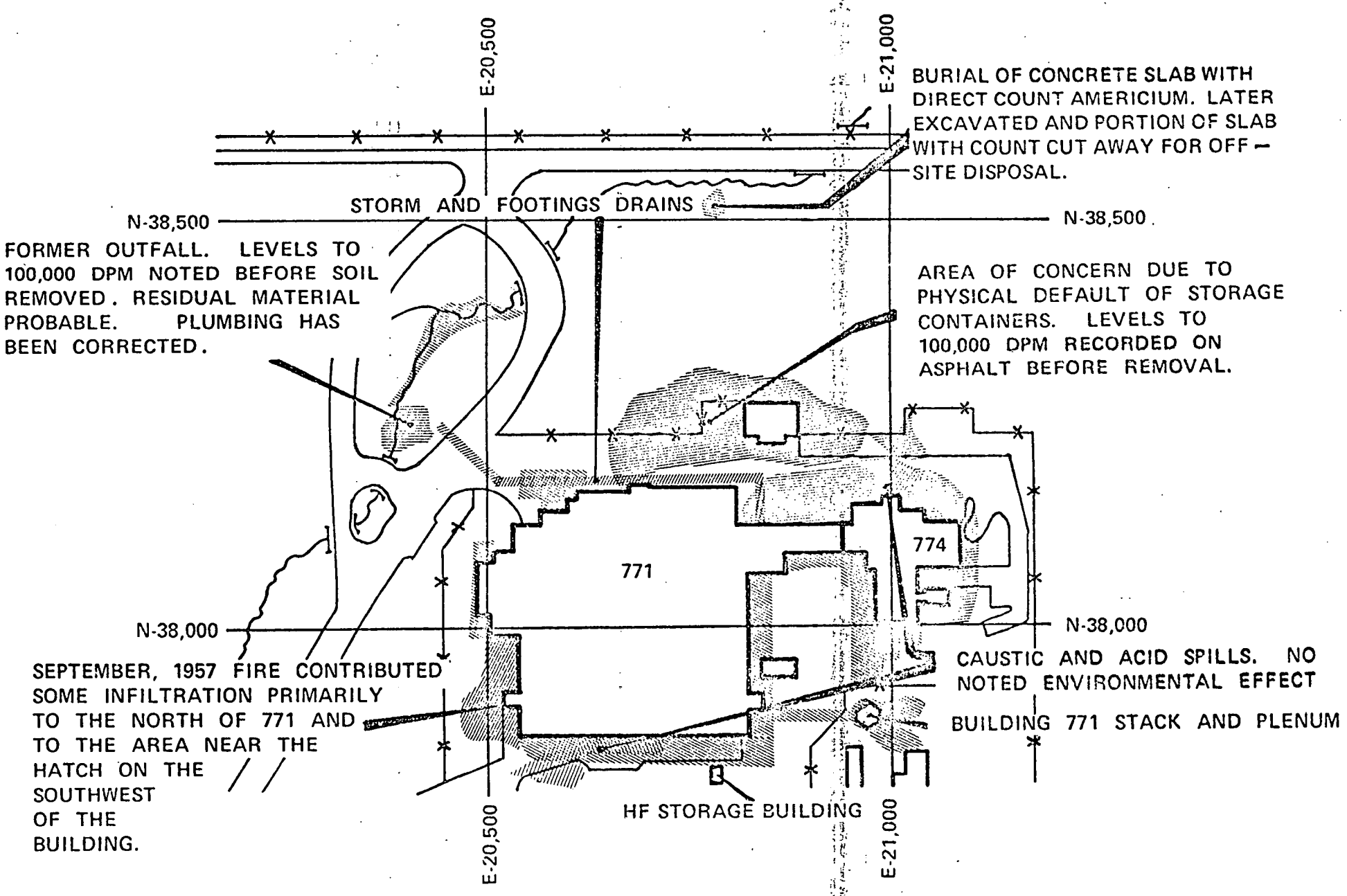
E-20,500
E-21,000
BURIAL OF CONCRETE SLAB WITH DIRECT COUNT AMERICIUM. LATER EXCAVATED AND PORTION OF SLAB WITH COUNT CUT AWAY FOR OFF – SITE DISPOSAL.
STORM AND FOOTINGS DRAINS
N-38,500
N-38,500
FORMER OUTFALL. LEVELS TO 100,000 DPM NOTED BEFORE SOIL REMOVED. RESIDUAL MATERIAL PROBABLE. PLUMBING HAS BEEN CORRECTED.
AREA OF CONCERN DUE TO PHYSICAL DEFAULT OF STORAGE CONTAINERS. LEVELS TO 100,000 DPM RECORDED ON ASPHALT BEFORE REMOVAL.
771
774
N-38,000
N-38,000
SEPTEMBER, 1957 FIRE CONTRIBUTED SOME INFILTRATION PRIMARILY TO THE NORTH OF 771 AND TO THE AREA NEAR THE HATCH ON THE SOUTHWEST OF THE BUILDING.
CAUSTIC AND ACID SPILLS. NO NOTED ENVIRONMENTAL EFFECT
BUILDING 771 STACK AND PLENUM
HF STORAGE BUILDING
E-20,500
E-21,000

MAP 1.

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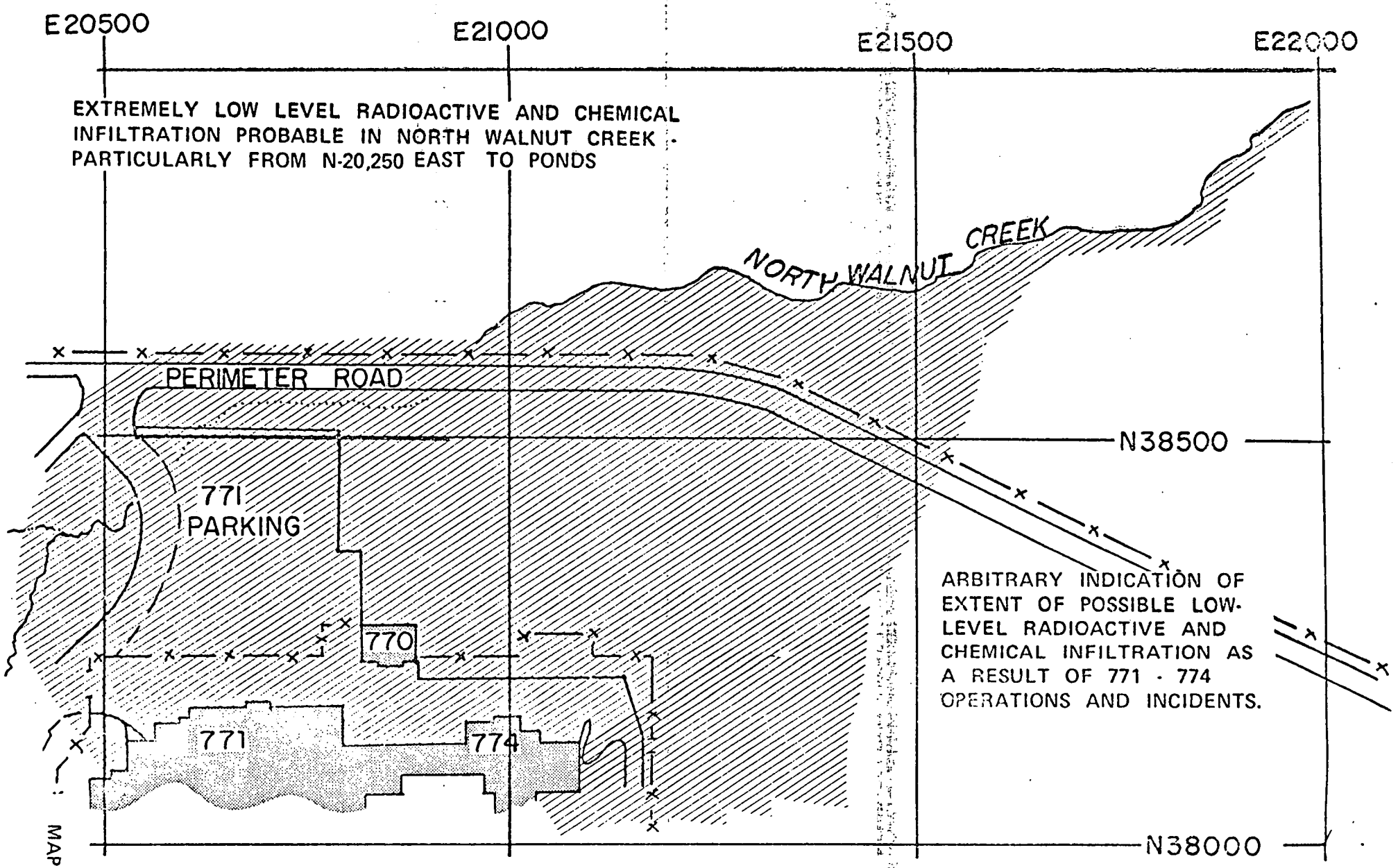
Map 1A

This map gives an arbitrary indication of possible affected areas as a result of operational incidents and accidents in the Buildings 770-771-774 area. As indicated, low level nitrate and radioactive infiltration is expected. Soil samples of the area justify this low-level assumption, with plutonium values ranging from undetectable to 64.9 dpm/g.

It must also be emphasized that the variables inherent in soil sampling (i.e., particle size, type of soil, physical location, vegetation cover, etc.) and the state-of-the-art do not permit wholesale drawing of conclusions as to levels, accurate isocurie contours, etc. It is the nature of the technology that a "high" sample could be detected immediately adjacent to an undetectable one and vice versa. Where such contours have been derived, by one means or another, they will be incorporated into this report for reference. Wherever possible, however, actual sample results should be the only judgment criterion and will be so presented herein.


E20500
E21000
E21500
E22000
EXTREMELY LOW LEVEL RADIOACTIVE AND CHEMICAL INFILTRATION PROBABLE IN NORTH WALNUT CREEK - PARTICULARLY FROM N-20,250 EAST TO PONDS
NORTH WALNUT CREEK
PERIMETER ROAD
N38500
771 PARKING
770
771
774
N38000
ARBITRARY INDICATION OF EXTENT OF POSSIBLE LOW-LEVEL RADIOACTIVE AND CHEMICAL INFILTRATION AS A RESULT OF 771 - 774 OPERATIONS AND INCIDENTS.

MAP 1A.

Map 2 (Buildings 701, 776-777, 778, and 779)

In June 1964, an explosion within a glovebox in Building 776 resulted in extensive release of plutonium to the interior and some to the exterior, primarily north of that building.

A fire on May 11, 1969, released plutonium to all of Building 776-777 and areas of Buildings 771, 778, and 779. The integrity of the buildings involved, however, remained essentially intact and very little environmental infiltration can be attributed to the actual fire. Subsequent extinguishing efforts, and cleanup did, however, provide some contribution (Map 2A).

These two incidents are primarily responsible for soil infiltration in this area. The majority of the affected soil has either been removed or covered with asphalt. As examples, in September 1969, approximately 320 tons of soil and asphalt (containing an estimated 14 mg Pu) were removed from the west side of Building 776. An asphalt-covered area of about 10,000 square feet, north of Building 776-777, has levels of radioactivity of about 700 dpm/g. When this area was surveyed, no particular "hot spots" were found but the material was somewhat deep in places, particularly around a drain in the dock area. A French drain north of Building 776 may have contributed to some plutonium infiltration below the surface although no surface expression has been noted. Radioactive levels of up to 80,000 dpm/100 cm^2 were noted in October 1971, north of the Building 776 compressor shed directly under the gravel and the soil was subsequently removed for disposal.

More recent incidents, such as process waste backing up into a stool and sink in Building 701 (June 1972) have also contributed some degree of infiltration to the area in the vicinity of that structure. Also there has been some minor spillage of carbon tetrachloride into the soil at the storage tank near the southwest corner of Building 701. No significant environmental consequences are expected from this spillage.

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Building 779 was erected over the site of one of the original solar evaporation ponds. During excavation (September 1962) levels of radioactivity ranging from 11 to 75 dpm/g were noted, and later, pools of water in these excavations had levels to 150 dpm/l. The radioactive material involved was mostly uranium.

With the exception of the recent tritium incident and minor involvement in the 1969 fire, only one other major incident of environmental significance has been documented in Building 779. In June of 1969, an improperly opened waste drum resulted in radioactive material spread to the first floor, utility room, dock and adjacent grounds, and walkways east and south of the building, mostly by personnel tracking. Levels up to 50,000 dpm/100 cm^2 were recorded, and a number of drums of soil were subsequently removed for off-site disposal.

Thus the entire Buildings 776-777, 778, and 779 areas (including substructures) must be considered at least partially infiltrated with radioactive materials primarily on the north side of the complex, the west side of Building 776, between Buildings 777 and 779, and the courtyard between Buildings 776-777 and 778.

Some chemical infiltration, notably nitrates, chromate, and particularly in and near Building 776, possible organics (CCl_4), is to be expected, particularly beneath and north of the buildings.

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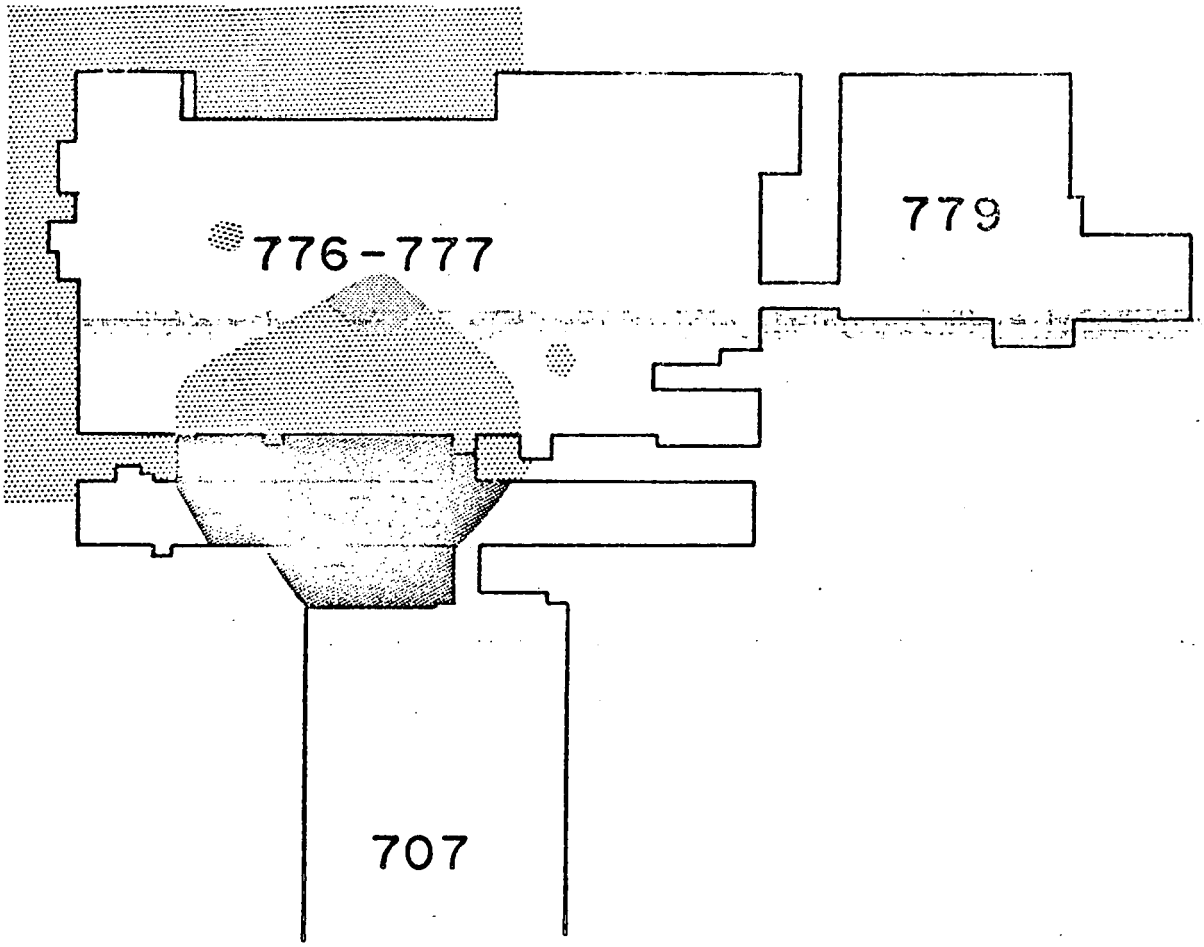
~80,000 DPM NOTED IN 1971. REMOVED.
ABOUT 10,000 SQUARE FEET, ASPHALT COVERED, ABOUT 700 DPM/G.
LOCATION OF OLD SOLAR EVAPORATION POND. 11 TO 75 DPM/G NOTED DURING CONSTRUCTION. PROBABLE HIGH NITRATE LEVELS.
PROCESS WASTE BACKUP, 1972. SOIL REMOVED.
IMPROPERLY OPENED WAST DRUM. UP TO 50,000 DPM NOTED, SOIL REMOVED.
(AREAS AFFECTED BY MAY '69 FIRE...SEE FOLLOWING MAP.)
779
776-777
N-37,500
E-20,500
778
ONE SOURCE OF RECENT TRITIUM INFILTRATION.
ARBITRARY "AREA OF CONCERN": NITRATES, CHROMATES, SOME Be, AND LOW LEVEL ORGANIC INFILTRATION EXPECTED
E-21,000
E-21,500

MAP 2.

ROOF AND OUTSIDE AREAS



10^5 to 10^6 cpm

10^4 to 10^5 cpm

10^3 to 10^4 cpm

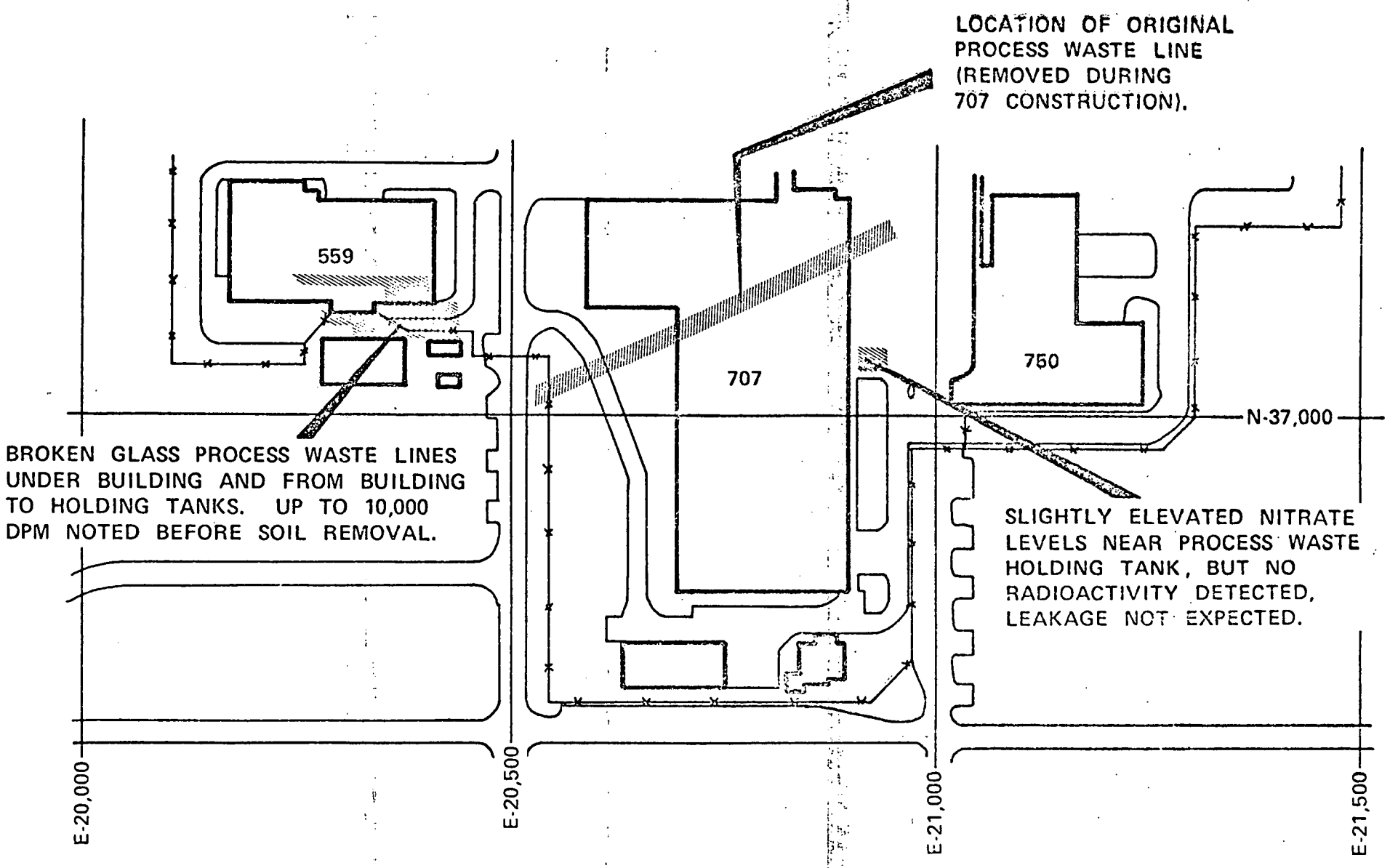
EXTERIOR AREAS OF 776-777 AND 778 AFFECTED IN AFTERMATH OF MAY, '69 FIRE.

MAP 2A.

Map 3 (Buildings 559 and 707)

The Service Laboratory Facility, Building 559, began operation in March 1968. Original process waste pipelines under the building were made of Pyrex® glass to combat a persistent corrosion problem. Operations and natural settling of the building have resulted in several breaks in this glass line, which are discussed in conjunction with Map 14.

Building 707, the newest production complex, has created no known environmental infiltration. Before construction, however, a section of the original process waste line (see Map 14) was removed and some residual material might be in residence. A sampling well (see Map 20) located near the process waste holding tank (between Buildings 707 and 750) has produced slightly elevated nitrate levels, but this could be due to a number of factors. No radioactivity has been detected in these samples, therefore, no leak or infiltration is assumed.

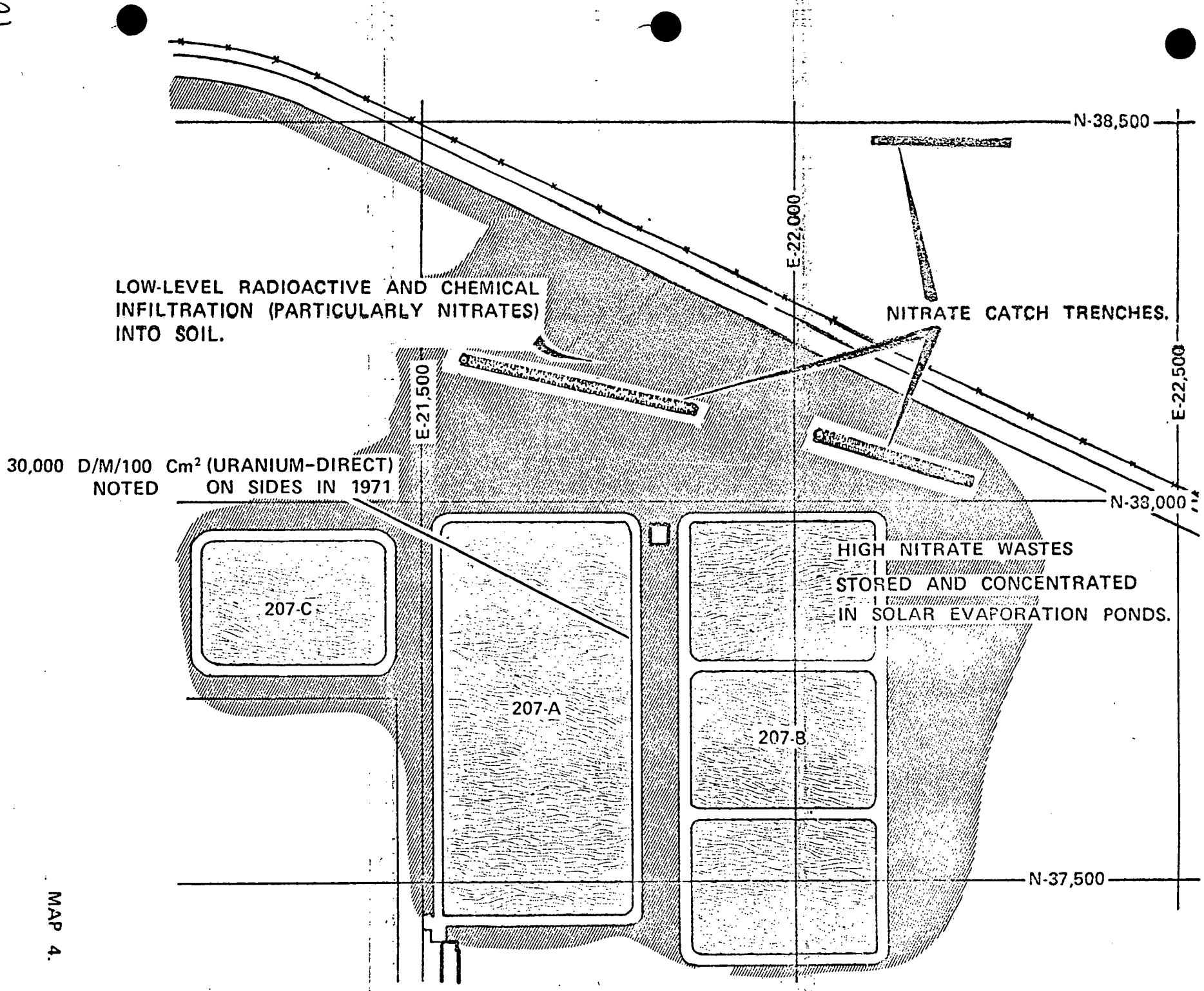

LOCATION OF ORIGINAL PROCESS WASTE LINE (REMOVED DURING 707 CONSTRUCTION).
559
707
750
N-37,000
BROKEN GLASS PROCESS WASTE LINES UNDER BUILDING AND FROM BUILDING TO HOLDING TANKS. UP TO 10,000 DPM NOTED BEFORE SOIL REMOVAL.
SLIGHTLY ELEVATED NITRATE LEVELS NEAR PROCESS WASTE HOLDING TANK, BUT NO RADIOACTIVITY DETECTED, LEAKAGE NOT EXPECTED.
E-20,000
E-20,500
E-21,000
E-21,500

MAP 3.

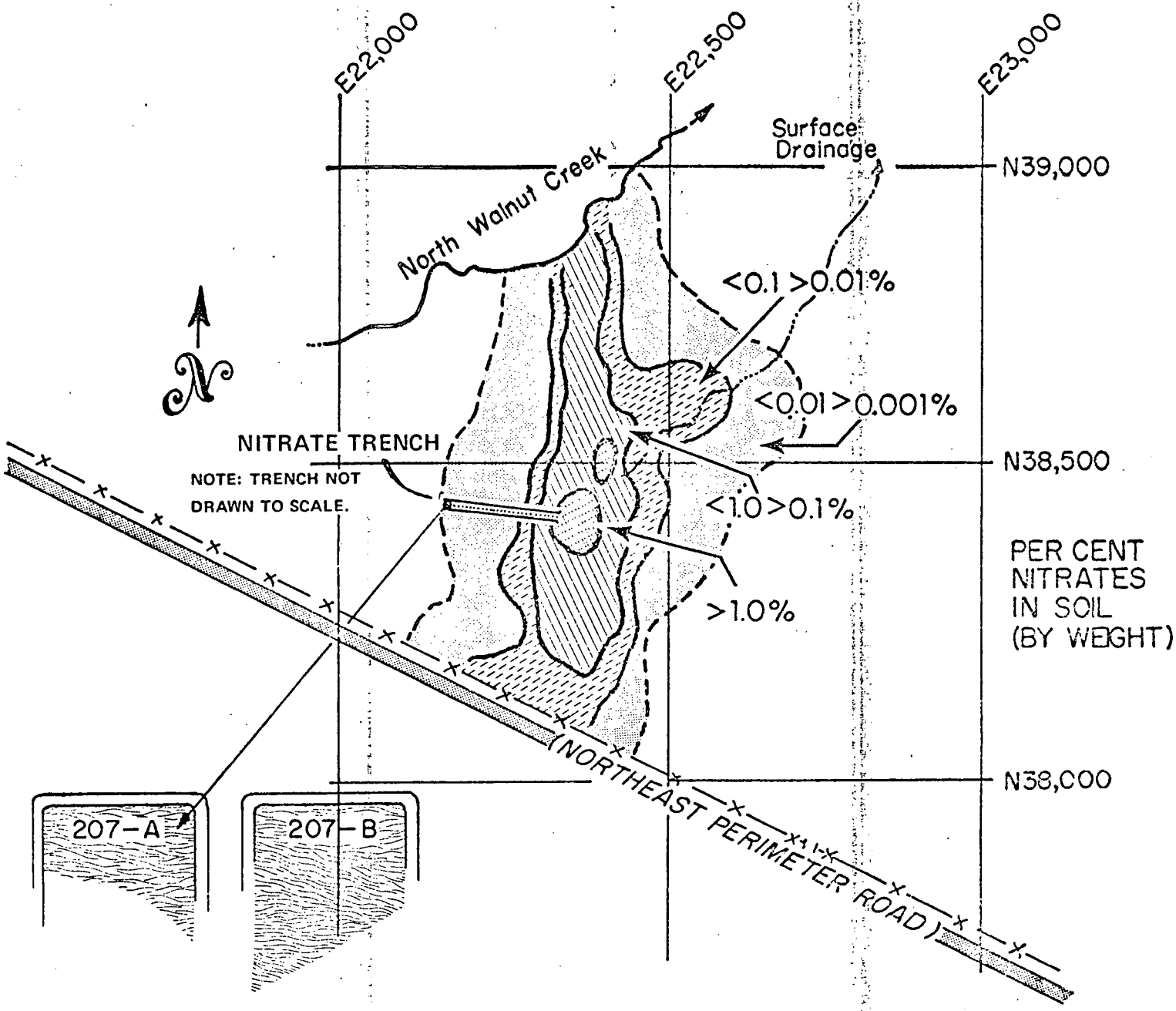
Map 4 (Solar Evaporation Ponds)

Since the plant's inception, high-nitrate wastes have been concentrated (by evaporation) in a series of solar-evaporation ponds and over a 20-year time span, some loss of integrity occurred. The leaks resulted in some infiltration, primarily chemical, of the soil under and around these ponds. High winds have also contributed some spread of material. A continuous program of cleaning and sealing the ponds has been necessary. In June of 1971, 30,000 dpm/100 cm^2 were noted at the high watermark on the west side of Pond 207-A, contributed mostly by uranium. Thus, in addition to nitrates, low level radioactive permeation of the soil is probable.

To minimize the nitrate invasion of North Walnut Creek, catch trenches have been placed downslope from the solar ponds. These trenches trap the nitrate-laden runoff which is then pumped back into the solar ponds. Map 4A details nitrate concentrations (percent of NO_3 in soil by weight) as determined by soil sampling (core samples). Again, without sampling every square inch of the affected area, these contours must be considered illustrative only.


N-38,500
E-22,000
E-22,500
LOW-LEVEL RADIOACTIVE AND CHEMICAL INFILTRATION (PARTICULARLY NITRATES) INTO SOIL.
NITRATE CATCH TRENCHES.
E-21,500
30,000 D/M/100 Cm² (URANIUM-DIRECT) NOTED ON SIDES IN 1971
N-38,000
HIGH NITRATE WASTES STORED AND CONCENTRATED IN SOLAR EVAPORATION PONDS.
207-C
207-A
207-B
N-37,500

MAP 4.


E22,000
E22,500
E23,000
Surface Drainage
N39,000
North Walnut Creek
<0.1 >0.01%
<0.01 >0.001%
NITRATE TRENCH
NOTE: TRENCH NOT DRAWN TO SCALE.
N38,500
<1.0 >0.1%
>1.0%
PER CENT NITRATES IN SOIL (BY WEIGHT)
(NORTHEAST PERIMETER ROAD)
N38,000
207-A
207-B

MAP 4A.

Map 5 (Storage Areas for Radioactive Materials [Excluding 903 Area])

Other than Buildings 771 and 774 and the 903 Area, two sites have been predominately used for storage of radioactive scrap for processing or waste for disposal.

An area east of the solar evaporation ponds is still utilized for storage of scrap for processing. In January 1969, 29 of these drums were found to be leaking with resultant levels of up to 200,000 dpm/100 cm^2. About 200 square feet of soil was removed to a depth of 3 to 5 inches in March 1970 for off-site disposal. The drums were then placed in cargo containers to protect them from the weather. Further leakage resulted in an area of approximately 1,000 square feet affected from 2,000 to 200,000 dpm/100 cm^2 in May 1971 and the soil was removed for off-site disposal. On June 21, 1973, a drum containing a nitric acid solution leaked, affecting an area of about 500 square feet, with levels ranging from about 2,500 dpm/100 cm^2 to in excess of the range of the detection instrument (greater than 2,000,000 dpm/100 cm^2). Approximately 40 drums of soil were removed for off-site disposal. A soil sample, taken after cleanup operations were completed, indicated 24 dpm/g.

The Building 663 storage area, east of Seventh Avenue (opposite Building 444) and the adjacent storage yard west of Seventh Avenue, have both been affected several times by punctured or leaking waste boxes and drums. Both uranium and plutonium solid wastes, oils, and coolants have been involved. The areas have been scraped and the soil removed, but low level residual plutonium and uranium are present.

Building 663, the storage and shipping facility, has also been affected due to punctured drums and broken waste lines. Thus a total of

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about 280,000 square feet is possibly involved, to a varying extent, with low level infiltration.

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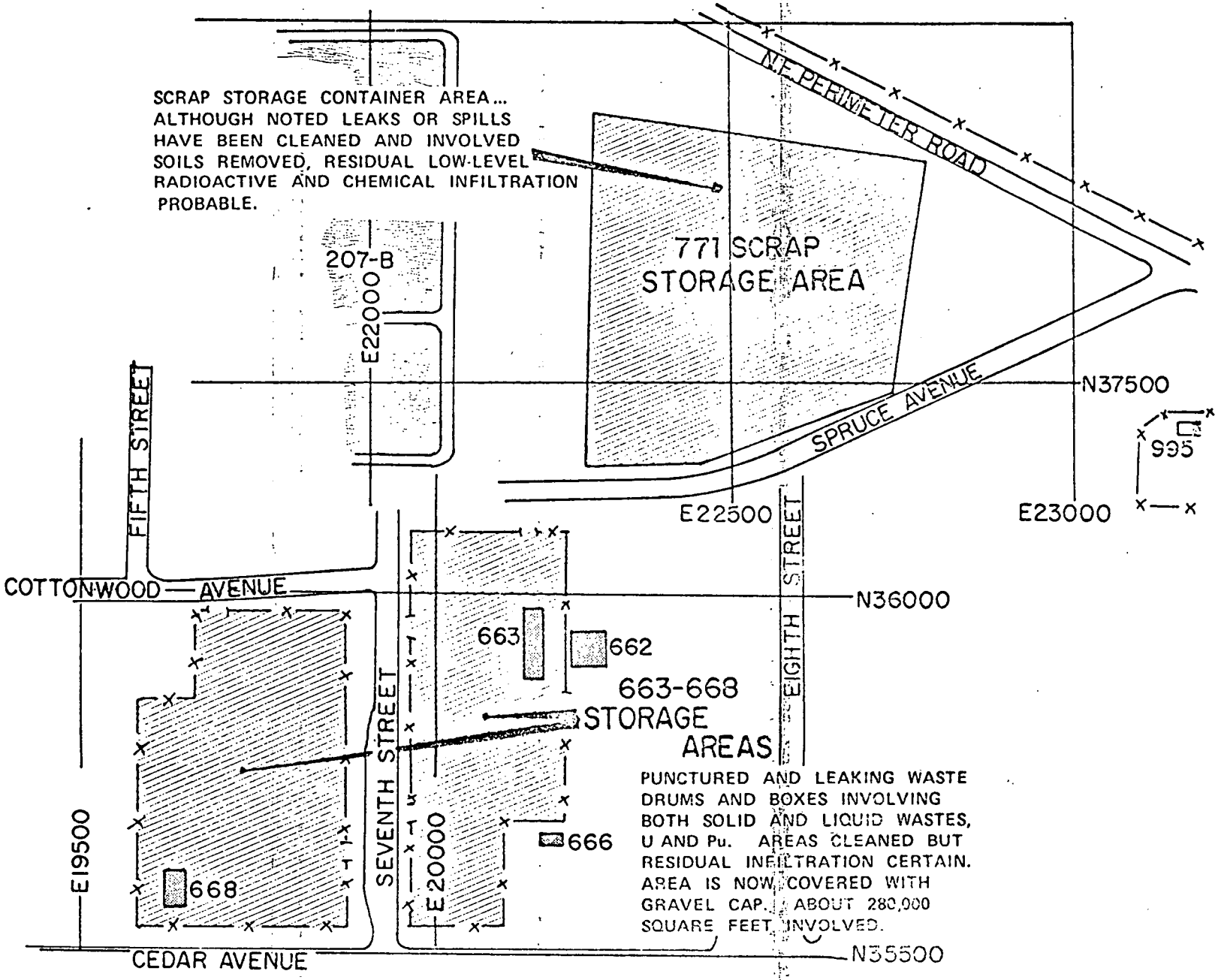
SCRAP STORAGE CONTAINER AREA... ALTHOUGH NOTED LEAKS OR SPILLS HAVE BEEN CLEANED AND INVOLVED SOILS REMOVED, RESIDUAL LOW-LEVEL RADIOACTIVE AND CHEMICAL INFILTRATION PROBABLE.
N.E. PERIMETER ROAD
771 SCRAP STORAGE AREA
207-B
E22000
N37500
SPRUCE AVENUE
995
E22500
E23000
FIFTH STREET
COTTONWOOD AVENUE
N36000
663
662
663-668 STORAGE AREAS
SEVENTH STREET
EIGHTH STREET
666
668
E19500
E20000
PUNCTURED AND LEAKING WASTE DRUMS AND BOXES INVOLVING BOTH SOLID AND LIQUID WASTES, U AND Pu. AREAS CLEANED BUT RESIDUAL INFILTRATION CERTAIN. AREA IS NOW COVERED WITH GRAVEL CAP. ABOUT 280,000 SQUARE FEET INVOLVED.
CEDAR AVENUE
N35500

MAP 5.

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Map 6 (Buildings 439, 440, and 444-447)

Depleted and enriched uranium and beryllium are the principal materials of concern to this area.

In 1953, high winds blew the lids off waste drums and uranium was released to the dock, driveway, and surrounding grounds. Direct count as high as 7,500 dpm/100 cm^2 and smears as high as 350 dpm were reported. The docks and sidewalks were cleaned up and the driveway areas seal-coated. A broken process waste line (June 1966) north of the building resulted in some possible infiltration as did leaking storage drums south of the building. An open ingot storage area east of Building 444 and a metal storage area south of the building have undoubtedly resulted in low-level infiltration of the soil, as has a uranium machine tool storage area west of the building.

In May 1960, a vacuum collector fire in Building 447 resulted in approximately 44 µCi depleted uranium deposited on the roof of the building. In December 1962, a uranium/beryllium release from Building 444 (due to use of an unfiltered hood) was noted.

Thus, these areas immediately adjacent to Buildings 439, 440, and 444-447, as well as the storage areas noted on Map 6, must be considered radioactively infiltrated to some degree as should the footings and foundations of these buildings.

Chemically, no specific incidents have been noted, but routine generation of nitrates and chromates would indicate at least the possibility of these materials being present in soil under and around these buildings.

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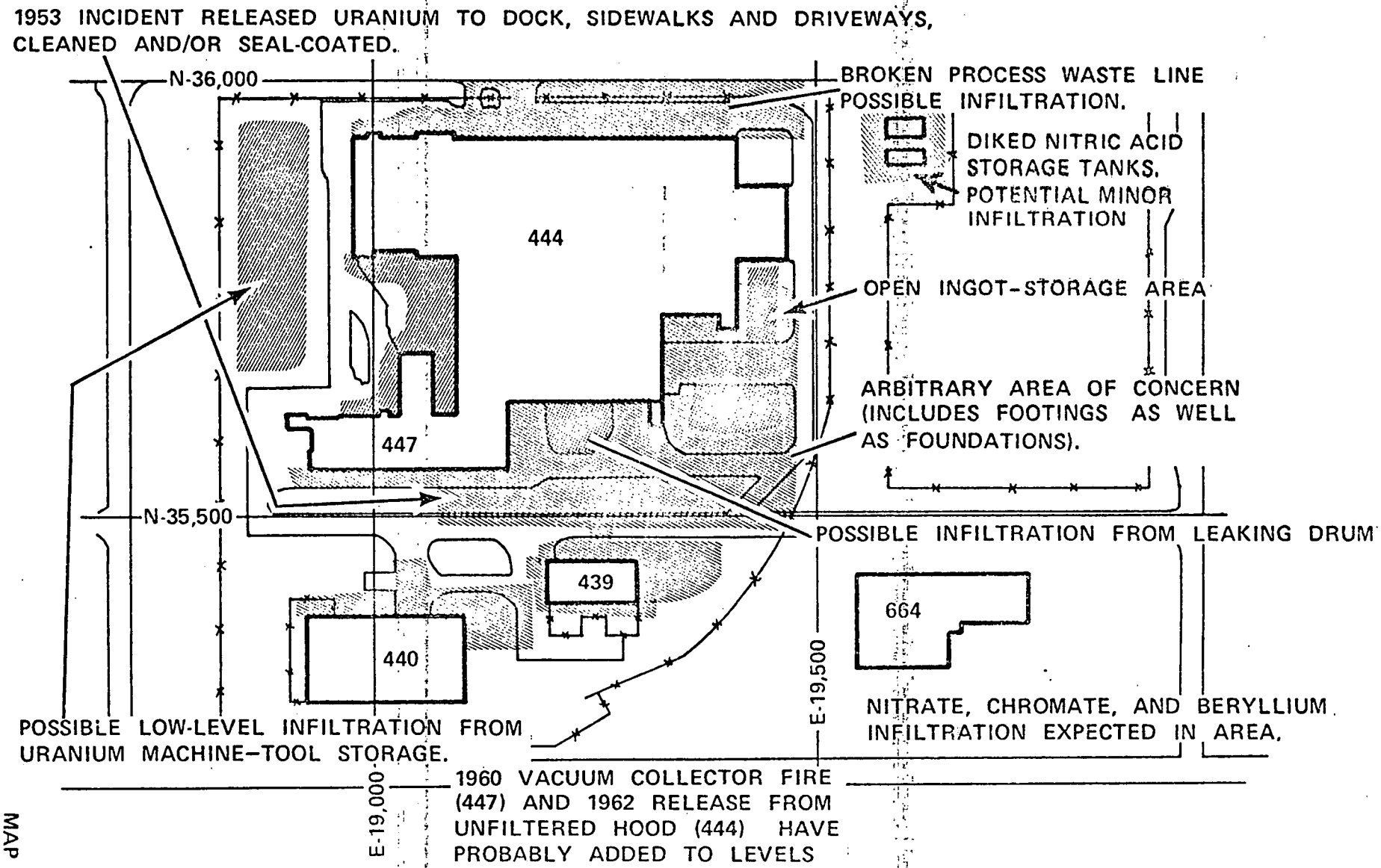

1953 INCIDENT RELEASED URANIUM TO DOCK, SIDEWALKS AND DRIVEWAYS, CLEANED AND/OR SEAL-COATED.
N-36,000
BROKEN PROCESS WASTE LINE POSSIBLE INFILTRATION.
DIKED NITRIC ACID STORAGE TANKS.
POTENTIAL MINOR INFILTRATION
444
OPEN INGOT-STORAGE AREA
ARBITRARY AREA OF CONCERN (INCLUDES FOOTINGS AS WELL AS FOUNDATIONS).
447
N-35,500
POSSIBLE INFILTRATION FROM LEAKING DRUM
439
664
440
E-19,500
NITRATE, CHROMATE, AND BERYLLIUM INFILTRATION EXPECTED IN AREA.
POSSIBLE LOW-LEVEL INFILTRATION FROM URANIUM MACHINE-TOOL STORAGE.
E-19,000
1960 VACUUM COLLECTOR FIRE (447) AND 1962 RELEASE FROM UNFILTERED HOOD (444) HAVE PROBABLY ADDED TO LEVELS IN THE VICINITY OF THESE BUILDINGS.

MAP 6.

Map 7 (Buildings 122, 123, 331, 334, 441, 442, 443, 551, and 554)

Building 122 (Medical Facility), with its extremely low level waste-liquid generation, operated with a 55-gallon drum as a waste tank. Rusting of this drum and subsequent leakage resulted in some low-level infiltration of soil under the building and the removal of a section of the floor inside (southeast corner) the building. Significant infiltration is not suspected and has not been detected in areas around the building.

Building 123 (Health Physics Laboratories) generates low-level radioactive liquid waste as well as chemical wastes. Known or suspected underground waste-line leakage has contributed some material to the soil beneath the building. Leakage, however, also appears to be into the lines due to high hydrostatic pressure, thus minimizing the potential.

Building 441 was originally a laboratory handling small quantities of radioactive material as well as quantities of various chemicals. Thus, the soil and piping beneath the building must be considered suspect in regard to both chemical and radioactive infiltration.

The Laundry, Building 442, is also potentially affected by both radioactive and chemical materials, notably depleted uranium and beryllium, and in 1964 the Laundry was infiltrated by enriched uranium, impregnated in clothes from Building 883. The soil in the vicinity of this building has also been affected by instances of radioactivity release. For example, in December 1963, rag-cleaning barrels stored near the building either leaked or spilled. The liquid drained east into the ditch on the northwest side of the building. Radioactivity was detected as far east as the east end of Building 551. Cleaning efforts and subsequent runoff has reduced concentrations in that area to a low level.

Building 443, the Steam Boiler Plant, has had no known radioactive material involvement. Routine operations do involve chemicals,

particularly sulfuric acid and sodium hydroxide. The only incident of note occurred when a quantity of sulfuric acid was spilled to the environs of the building. The acid drained eastward (on the south side of Building 442) to a trap dug in the center of the lot which is now used for Building 444 parking. This soil in the area would undoubtedly be somewhat acidic, but no adverse effect on the environment has been noted.

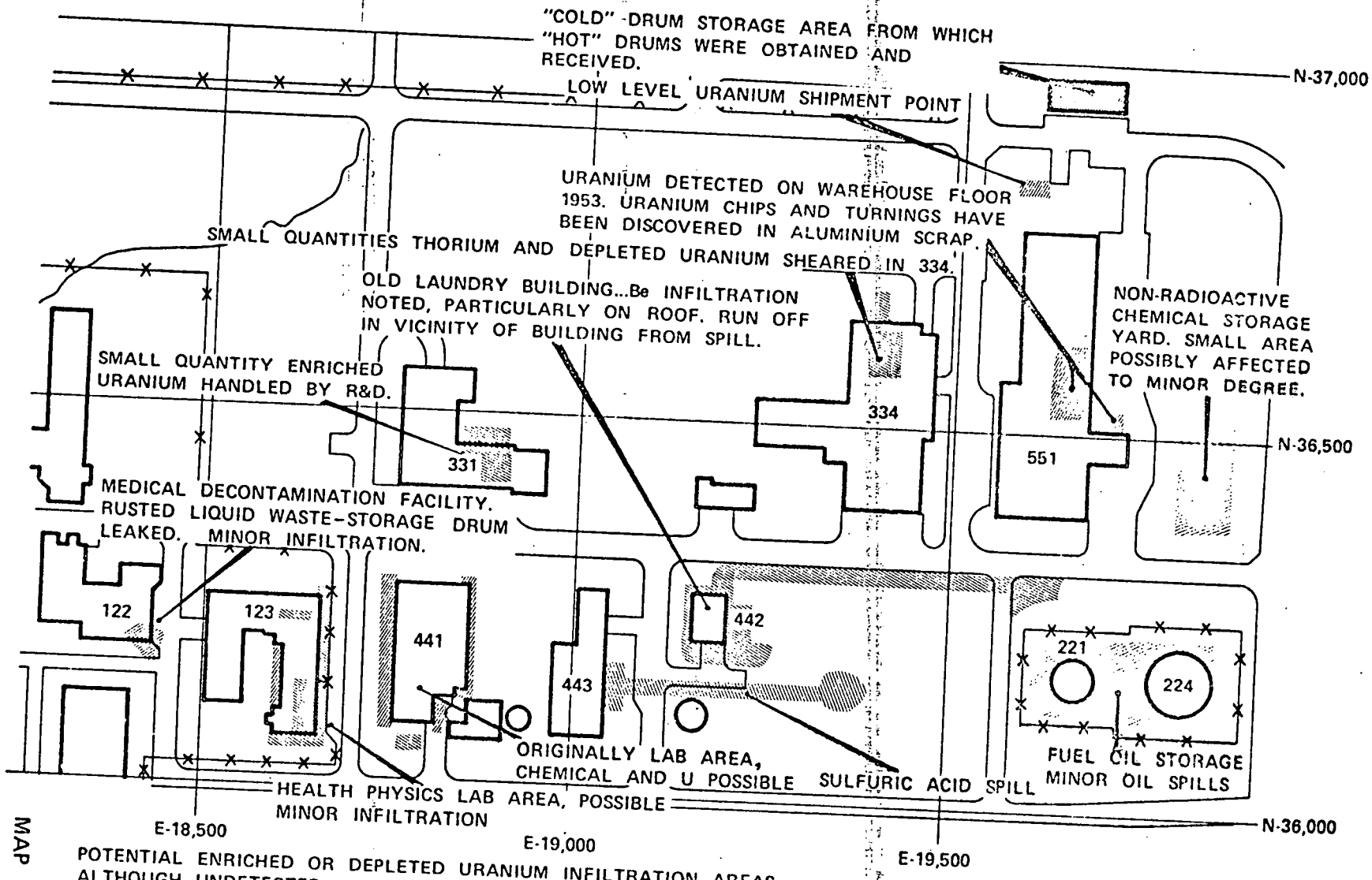
A portion of Building 331, the Plant Garage, was at one time used for a special R&D effort involving depleted and enriched uranium. No incidents or releases were noted during this operation and no environmental residue is expected. Due to the repair and storage of vehicles there is possibility of organics such as oil and gasoline in the soil beneath the building.

Building 334, the main Maintenance Shop, was also used for special work involving the shearing of some depleted uranium. Some thorium has also been handled in Building 334, again, with no known incident. No environmental encroachment of any material has been detected or is expected as a result of operations in this building.

The Warehouse, Building 551, and adjacent grounds, have been areas of concern several times. For example, detectable uranium was discovered on the Warehouse floor in April 1953. Uranium chips and turnings were discovered in an aluminum scrap pile near the Warehouse in 1963 and again in 1964. These were removed and the grounds cleaned. In July 1963 and again in 1970, Rocky Flats received equipment and drums from off site which contained uranium above the Rocky Flats acceptable level. In 1970 the entire shipment of 55-gallon drums was returned to that vendor. These and other minor incidents lead to at least suspect areas under and around Buildings 551 and 554 (where the "hot" drums were received). A small drum storage area east of Building 552 is suspect for the same reason.

38

There have been some minor leaks and spills from drums and storage containers in the non-radioactive chemical storage area east of Building 551. While a small area might have been affected, quantities involved have been so small that no impact has been noted nor expected. This area is used primarily to store drum quantities of acids, oils, soaps, and solvents.



MAP 7.

POTENTIAL ENRICHED OR DEPLETED URANIUM INFILTRATION AREAS. ALTHOUGH UNDETECTED, OPERATIONS PERFORMED IN THE NOTED AREAS MAKE LOW-LEVEL INFILTRATION A PROBABILITY.

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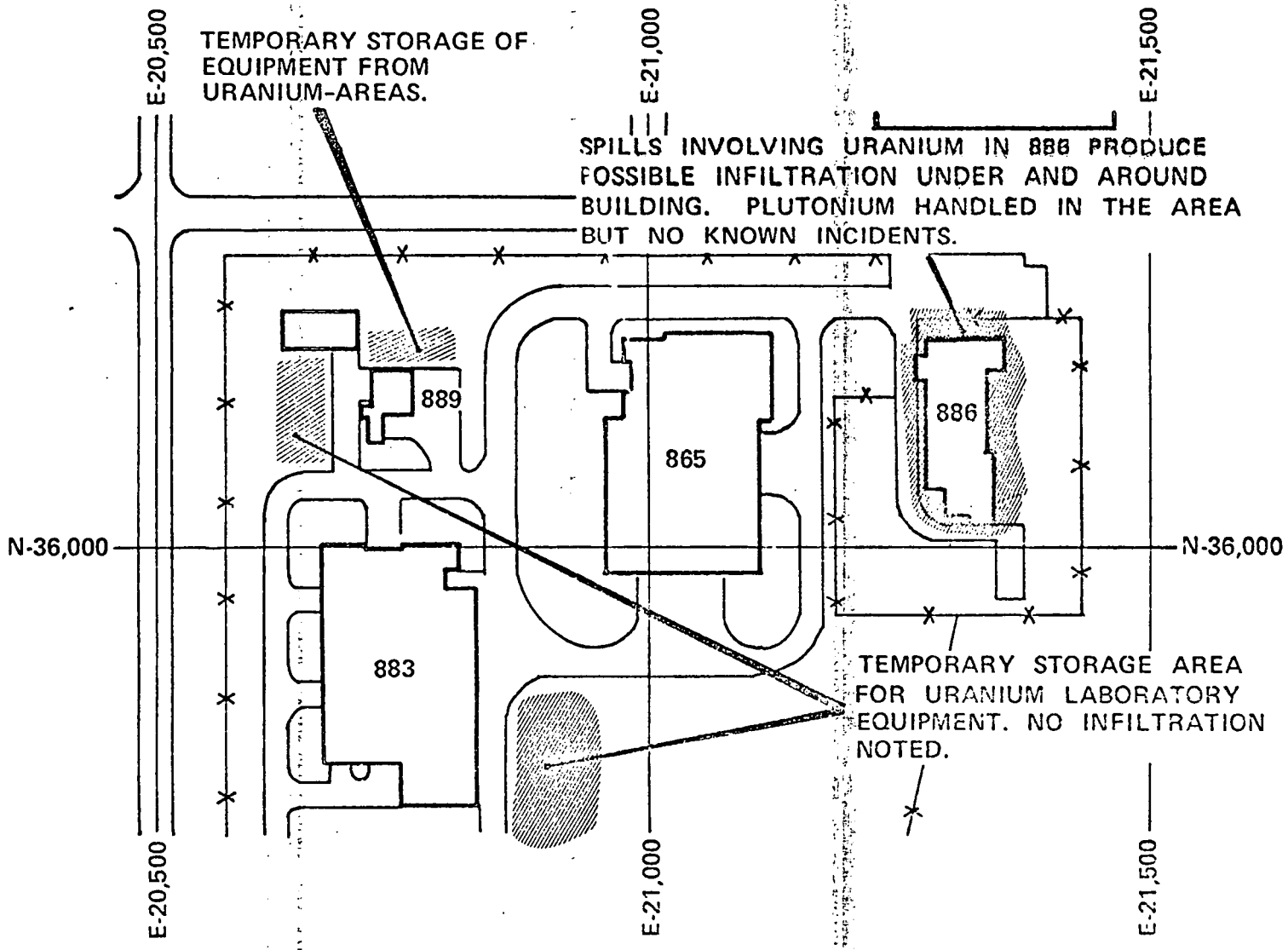
Map 8 (Buildings 865, 883, 886, and 889)

Due to the nature of operations in these buildings, soil infiltration is expected to some degree under and possibly around these buildings. Spills involving uranium in Building 886 have occurred, with an inherent possibility of substructure infiltration. No specific incidents have been documented in the other buildings (with the exception of a January 1969 incident wherein the roofing was blown off Building 889 with no environmental effect). At one time, however, some equipment from a uranium laboratory was stored outside (just east) of Building 883 and west of Building 889. Present practice includes temporary storage of equipment from uranium areas on a pad north of Building 889 prior to processing. Therefore, these would also be areas of interest, although no incident or infiltration has been noted.


E-20,500
E-21,000
E-21,500
TEMPORARY STORAGE OF EQUIPMENT FROM URANIUM-AREAS.
SPILLS INVOLVING URANIUM IN 886 PRODUCE POSSIBLE INFILTRATION UNDER AND AROUND BUILDING. PLUTONIUM HANDLED IN THE AREA BUT NO KNOWN INCIDENTS.
889
865
886
883
N-36,000
N-36,000
TEMPORARY STORAGE AREA FOR URANIUM LABORATORY EQUIPMENT. NO INFILTRATION NOTED.
E-20,500
E-21,000
E-21,500

MAP 8.

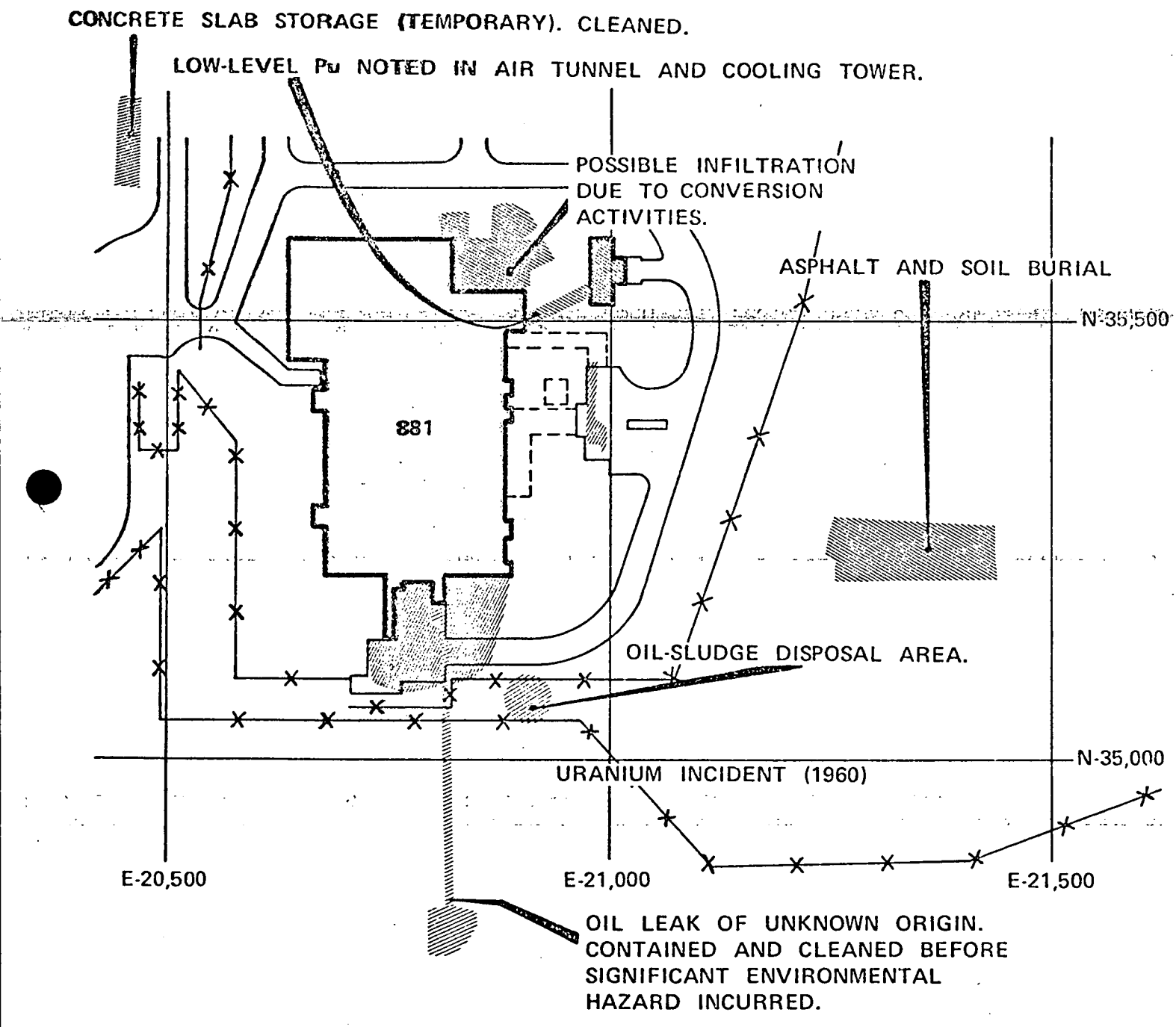
DRAFT

Map 9 (Building 881)

Building 881, originally a production building, was partially converted to a general support building in 1964. Although few incidents involving the building have been documented, it represents an area of interest, primarily due to the age of the structure (one of the original plant buildings). Both uranium (east dock February 1960) and plutonium (laboratory area October 1961 and 1968) incidents have been noted in the building and waste lines have been broken with resultant probable infiltration. Low levels of plutonium have been detected in the air tunnel and the cooling tower northeast of the building.

In addition to burial sites (see map), some exterior areas near Building 881 have been involved with radioactive material. An area of several hundred square feet northwest of the building was involved in 1958 when a concrete slab, removed from the east side of Building 776, was deposited there. The slab was broken up and removed and the area cleaned. Conversion activities also resulted in some possible infiltration, primarily to the northeast of the building.

In May 1973, oil (#6 fuel oil) from an undetermined source was discovered on the hillside below Building 881. Prompt action prevented the spread of the oil into Woman Creek or any holding pond. Leak tests on the Building 881 fuel tank and lines (the only known possible sources) did not show any leakage, but to date the oil continues to emerge through the Building 881 footings drain. A concrete skimmer dam has been built to trap the oil, which drains in extremely small quantities. The oil-soaked straw which was used to trap the material, as well as most of the soil involved, has been removed.


CONCRETE SLAB STORAGE (TEMPORARY). CLEANED.
LOW-LEVEL Pu NOTED IN AIR TUNNEL AND COOLING TOWER.
POSSIBLE INFILTRATION DUE TO CONVERSION ACTIVITIES.
ASPHALT AND SOIL BURIAL
N-35,500
881
OIL-SLUDGE DISPOSAL AREA.
N-35,000
URANIUM INCIDENT (1960)
E-20,500
E-21,000
E-21,500
OIL LEAK OF UNKNOWN ORIGIN. CONTAINED AND CLEANED BEFORE SIGNIFICANT ENVIRONMENTAL HAZARD INCURRED.

MAP 9.

Map 10 (Buildings 991 and 995)

Building 991 and the associated storage vaults (tunnels 996, 997, 998, and 999) are also original plant structures and thus under suspicion due to age. Incidents involving very small quantities of plutonium, as well as uranium and beryllium, have been noted in Building 991, and extensive research activities have undoubtedly spread some trace concentrations of materials in the vicinity of the building.

Although radioactive materials have been continuously stored in the vault areas, routine surveys have indicated that with the possible exception of 996, which might be slightly uranium infiltrated, the vaults have remained remarkably "cold." Any environmental leakage has been in rather than out as determined by salt infiltration into the tunnel areas.

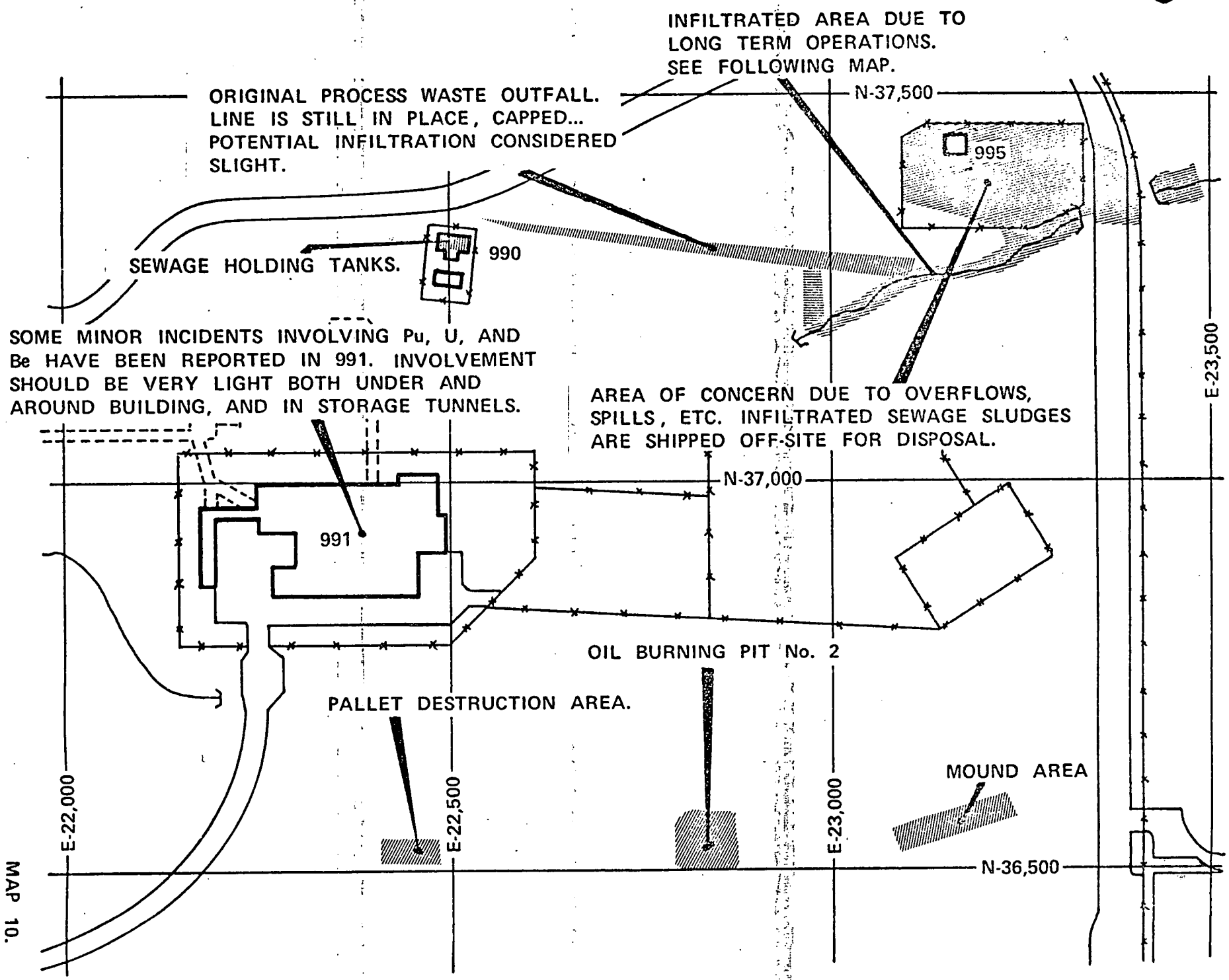
Building 995, the Sewage Treatment Facility, has historically been the recipient of effects from incidents in other areas of the plant. For example, the overflow incident in Building 701 (June 1972) contributed elevated levels of radioactive material (plutonium) to the Building 995 effluent and drying beds. In 1972, plumbing changes were initiated to channel all wastes through Building 995. The increased load thus generated lead to increasing radioactivity levels in sewage sludges which are shipped off site for disposal. Surge overflows and incidents involving spillage of the dried or drying sludge have created an area of concern which extends from the outlet of the South Walnut Creek diversion culvert to and through the B-series holding ponds, and surrounding the treatment area including both sides of the perimeter road east of Building 995.

The original process waste outfall (from Building 774) was located just west of the Building 995 outfall. The line was later rerouted to discharge further upstream. In 1972, the line was routed through Building 990 and then, through the sanitary sewer lines, into Building 995. The abandoned line is still in place. The area of the original outfall as well as the abandoned line are noted on Map 10 as areas of interest.

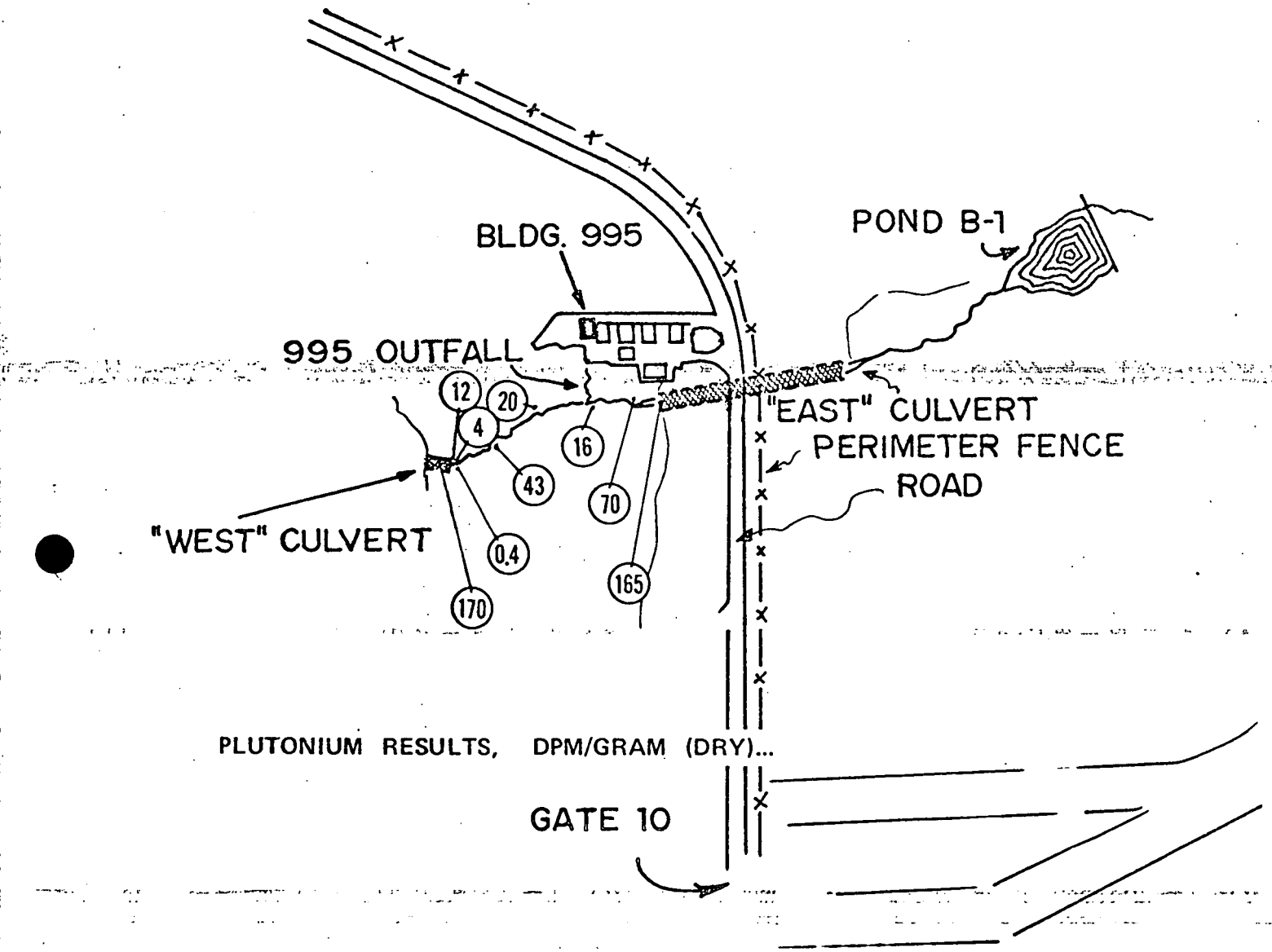
Map 10A details soil sample results from a recent survey in the vicinity of Building 995. These results are only illustrative, as actual levels vary with flow rates through the creek bed.

The B-series holding ponds are located in this area. Sediment sample results from all holding ponds taken in 1971 by the Radiobiology Department of Colorado State University (CSU), are detailed in Map 10B. The values given are questionable due to the analytical technique employed. Values shown may be high due to the presence of isotopic uranium or low due to inadequate sampling technique.

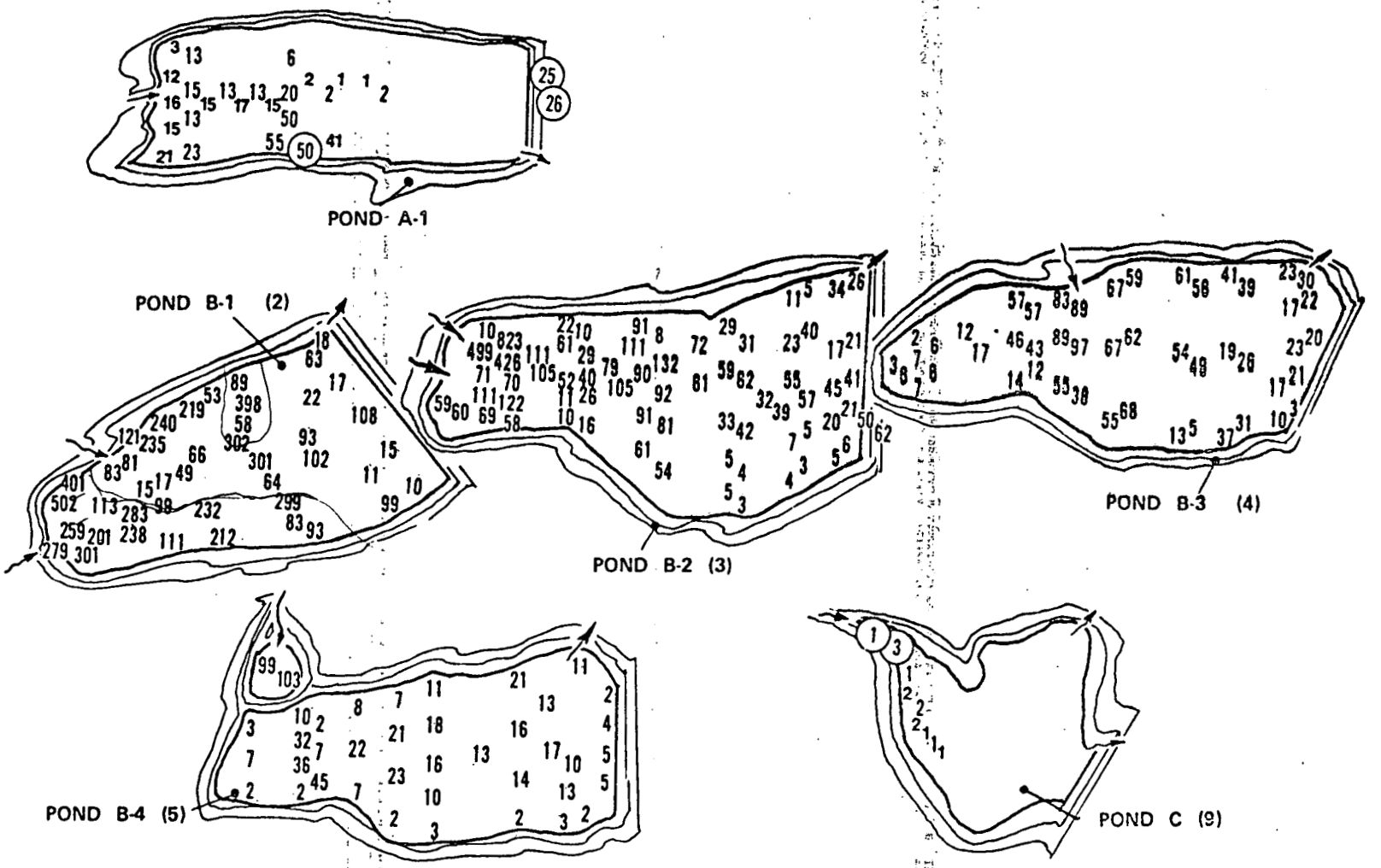
Regardless of the accuracy of the values shown in Map 10B, the B-series ponds must be considered an area of concern regarding both chemical and radioactive infiltration. Studies have shown that these ponds have performed what they were designed to do, provide residence time and holding capacity to allow materials to settle out, and in so doing have become infiltrated with those materials. It should be noted that the concentrations decrease throughout the system, which is further indication of the effectiveness of the ponds.


INFILTRATED AREA DUE TO LONG TERM OPERATIONS. SEE FOLLOWING MAP.
ORIGINAL PROCESS WASTE OUTFALL. LINE IS STILL IN PLACE, CAPPED... POTENTIAL INFILTRATION CONSIDERED SLIGHT.
N-37,500
995
990
SEWAGE HOLDING TANKS.
SOME MINOR INCIDENTS INVOLVING Pu, U, AND Be HAVE BEEN REPORTED IN 991. INVOLVEMENT SHOULD BE VERY LIGHT BOTH UNDER AND AROUND BUILDING, AND IN STORAGE TUNNELS.
AREA OF CONCERN DUE TO OVERFLOWS, SPILLS, ETC. INFILTRATED SEWAGE SLUDGES ARE SHIPPED OFF-SITE FOR DISPOSAL.
E-23,500
N-37,000
991
OIL BURNING PIT No. 2
PALLET DESTRUCTION AREA.
MOUND AREA
E-22,000
E-22,500
E-23,000
N-36,500

MAP 10.


BLDG. 995
POND B-1
995 OUTFALL
"EAST" CULVERT
PERIMETER FENCE
ROAD
"WEST" CULVERT
12
20
4
16
43
70
0.4
165
170
PLUTONIUM RESULTS, DPM/GRAM (DRY)...
GATE 10

MAP 10A.



PLUTONIUM CONCENTRATIONS IN HOLDING POND SEDIMENTS (PICOCURIES/GRAM DRY) CONSECUTIVE SAMPLES TAKEN IN APRIL AND MAY, 1971, BY RADIOBIOLOGY DEPT., COLORADO STATE UNIVERSITY. PONDS ARE NOT DRAWN TO SCALE.

NOTE: These values may be high due to the presence of isotopic uranium or low due to inadequate sampling technique.

MAP 10B.

Trenches T-2 through T-8 (1954-1968)

The trenches were disposal sites for approximately 100,000 kg of sanitary sewage sludge and about 275 flattened empty drums contaminated with uranium. Earlier pits involve mostly uranium with an increasing plutonium fraction in later pits. Activity ranges from 800 to 8,000 dpm/g. T-4 also contains some uranium-plutonium infiltrated asphalt planking from the 207 ponds. Estimated total alpha radioactivity is between 100 and 150 mCi.

Asphalt Disposal Area (1969)

Approximately 320 tons of plutonium-infiltrated asphalt and soil (from the Building 776 fire, May 1969) buried under 1 to 2 feet fill dirt. Less than 1 mCi plutonium is estimated to be dispersed in approximately 250 cubic yards of material with an estimated alpha activity of about 7 dpm/g.

Soil Burial (1972)

Approximately 60 cubic yards of plutonium-infiltrated soil from the Building 774 waste storage-tank area, now covered with about 3 feet of fill dirt. Estimated activity less than 250 dpm/g (total long-lived alpha). This soil was placed on top of the asphalt disposal area and covered with approximately 3 feet of fill dirt.

Incinerator Ash Pits I-1 through I-4 (1952-1968)

Estimated 100 grams depleted uranium burned with general combustible waste over 16-year period. Ashes buried in trenches.

Map 11 (Burial Sites - Except the 903 Area)

Locations where radioactive materials or chemicals have been deliberately buried or contained are detailed on Map 11. Detailed descriptions of each burial site, except the 903 Area which is discussed separately, are as follows:

Oil Burning Pit No. 1

Ten drums of oil containing depleted uranium were burned in August 1956 and the residue covered with backfill.

Oil Burning Pit No. 2 (1957 and 1961-1965)

A total of 1,082 drums of oil containing uranium were burned. The residues and some flattened drums were covered with backfill.

Mound Area (1954-1958)

A total of 1,405 drums of oil and solid waste were buried. Mostly depleted uranium with some enriched uranium and suspected low-level plutonium in this area. Complete retrieval and off-site disposal were achieved in May 1970 with no plutonium detected. A proposal to construct a new holding pond in this area resulted in sampling the soil in the vicinity of the excavated mound. Results ranged from 0.8 to 112.5 dpm/g and are thought to be due to infiltration from the 903 Area rather than to an influence from the mound or oil disposal pit (No. 2).

Trench T-1 (1954-1962)

Approximately 25,000 kg of depleted uranium chips in 125 drums were deposited in this trench and covered with about 2 feet of fill dirt.

Original Sanitary Landfill (1952-1968)

An estimated 20 kg depleted uranium ash is buried along with normal plant waste, including small quantities of various chemicals. The 20 kg of depleted uranium resulted when 60 kg was inadvertently burned and only 40 kg was recovered.

Oil Disposal Pit (1958)

Approximately 30 to 50 drums of oil sludge from a storage tank cleanout were emptied into a pit, which was then backfilled. No radioactivity involved.

Sanitary Landfill (Started in 1968)

From August 1968 to February 1970, approximately 1,000 kg of sanitary sewage sludge (800 to 8,000 dpm/g) were buried in the landfill. (Estimated total of 1 to 1.5 mCi alpha radioactivity buried with sludge.) Estimated annual (Dow/contractor) waste is 9,000,000 pounds. Materials with less than minimum detectable radioactivity levels (500 dpm/60 square centimeters direct or 50 dpm/square foot smear) are accepted for burial. Recent surveys have also disclosed other radioisotopes (e.g., tritium) in small quantities.

Lithium Destruction Areas (1956-1970)

Approximately 400 to 500 pounds of metallic lithium were destroyed and the residues, primarily non-toxic lithium carbonate, buried. Smaller quantities of other reactive metals (sodium, calcium, and magnesium) and some solvent type chemical compounds were also destroyed in this location.

[redacted]

Scrap Metal Disposal (Approximately 1958)

Scrap metal components, mostly from original construction, were buried in this area. Although no detectable radioactive or chemical materials were observed, some pieces were recovered from process areas and low level radioactivity of a small percentage of the scrap is possible.

Cooling Tower Blowdown Retention Ponds

These are small ponds which were used to contain water from cooling towers. Hexavalent chromium is present. Some small quantity of lithium was also destroyed in the two eastern-most ponds. These ponds were covered with fill.

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ADMIN RECORD

Map 12 (903 Storage Area)

Most of this area is now covered with an asphalt pad. It is the primary source of both on and off-site plutonium. From 1958 through 1967, approximately 5,240 drums of oil containing radioactivity were stored in this location. Of these drums, about 3,570 contained plutonium. The leakage of this material via corroded drums resulted in the concentrations described here.

Of the approximately 85 grams of plutonium originally deposited at the site, an estimated 68 grams remain dispersed over an area of 98,000 square feet, which was covered with asphalt and fill material in November 1969.

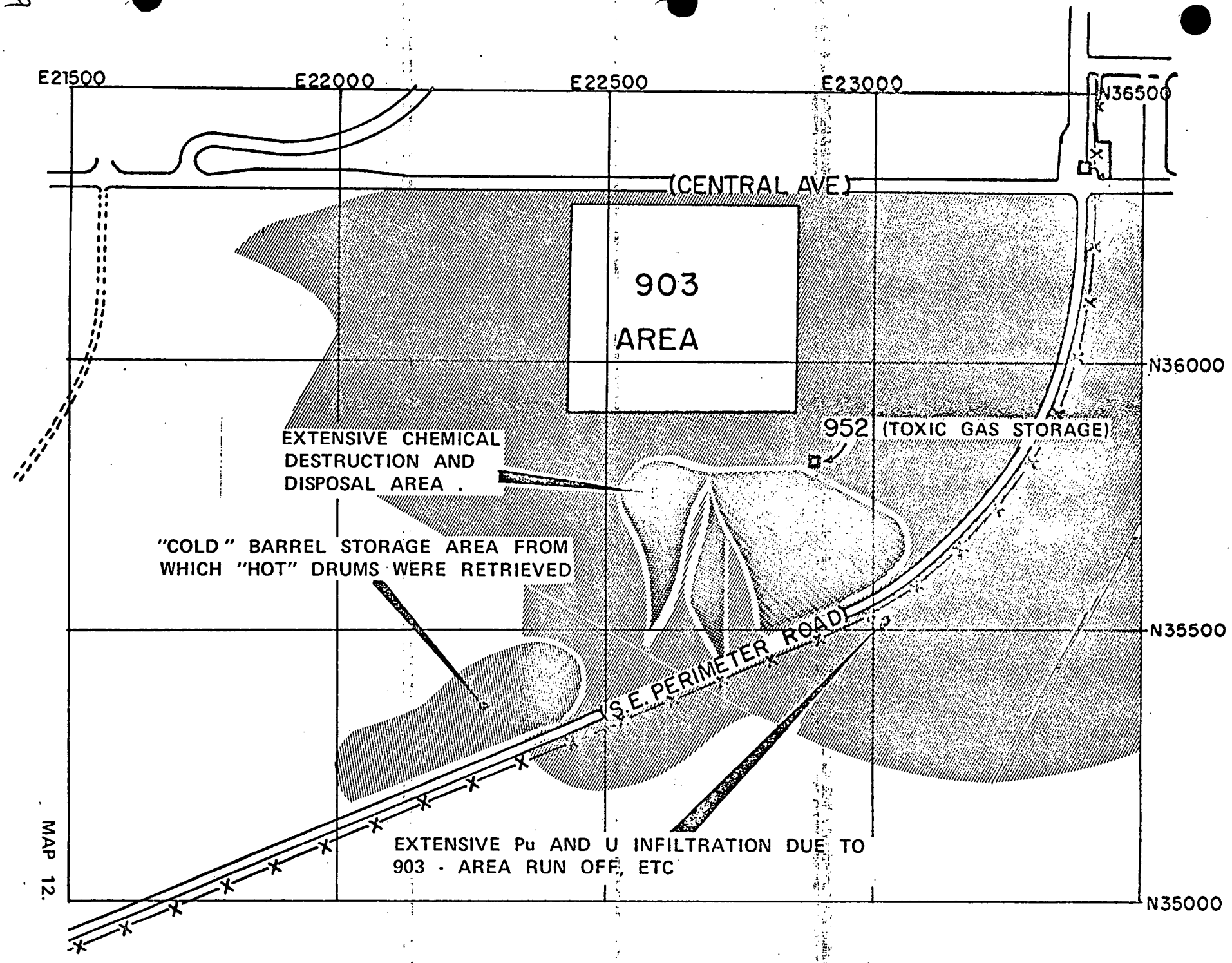
During the removal of the corroded drums and the subsequent covering operations, some radioactive material was resuspended and distributed by wind action to the east of the present pad area. Transport by runoff of rain and snow melt was also observed. The total quantity of ^{239}Pu dispersed in soil other than that covered by the pad is estimated to be less than 16 grams spread over a total area of over 2,000 acres. Inside the Rocky Flats boundary, about 672 acres contain nearly half the estimated plutonium. The remainder is spread over about 1,400 acres of public and private property.

In conjunction with the radioactive infiltrations noted in the original survey, further work has confirmed additional "hot spots" south of the actual pad area (Map 12A). The values indicated and contoured on this map were determined by FIDLER survey, and extrapolated from the detection of radiations emitted from americium. Total plutonium in this area has been estimated to be 7 grams as determined by a rough mechanical interpretation of the preliminary data.

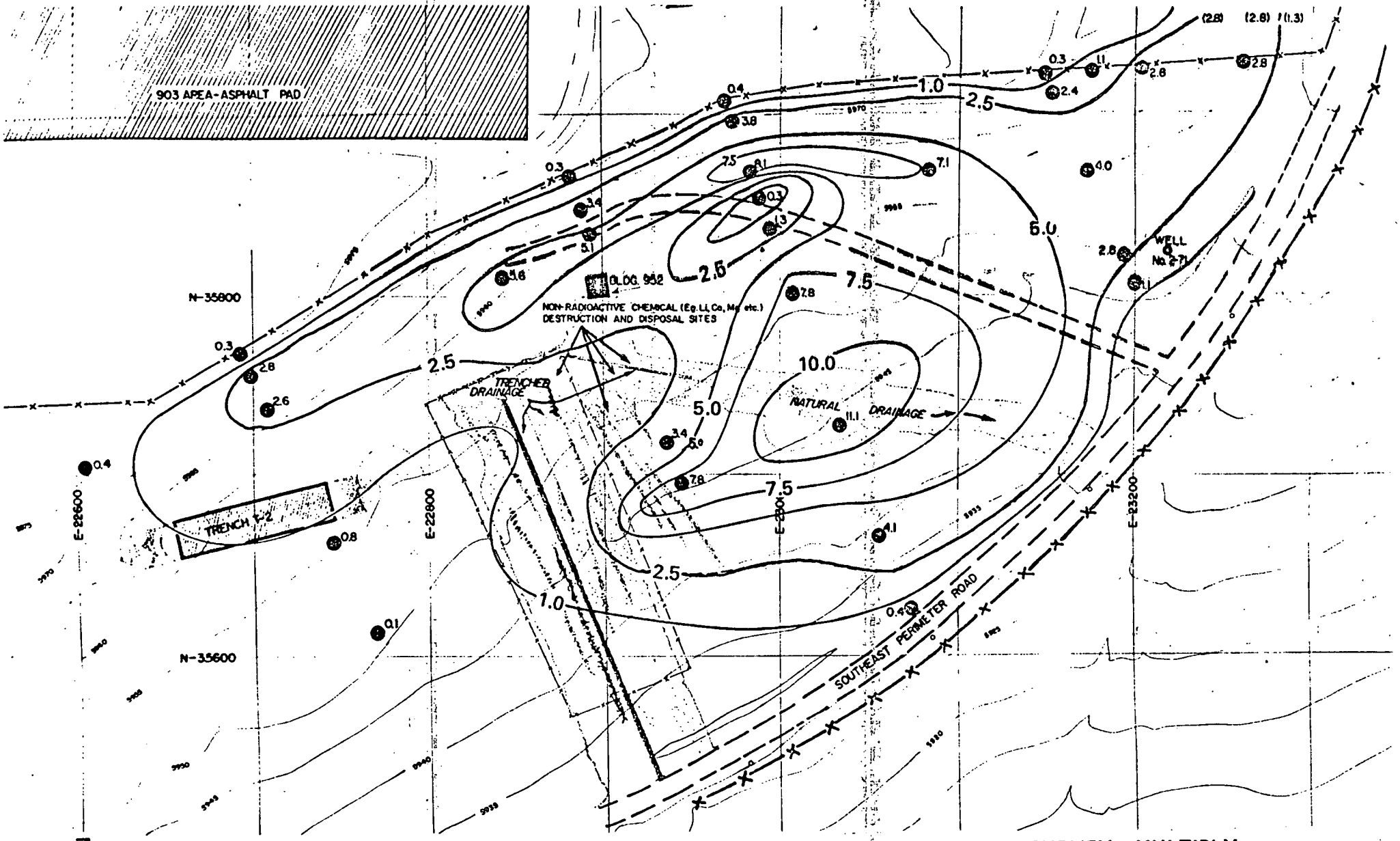
The area has also been extensively used as a chemical destruction and disposal area. Type and quantities of materials disposed here are unknown, but considerable quantities of metals such as lithium, calcium, and

[redacted]

magnesium are known to have been destroyed in the area since 1966. Thus chemical infiltration of the soil is a certainty, but no environmental detriment has been noted.


E21500
E22000
E22500
E23000
N36500
(CENTRAL AVE)
903
AREA
N36000
952 (TOXIC GAS STORAGE)
EXTENSIVE CHEMICAL
DESTRUCTION AND
DISPOSAL AREA .
"COLD" BARREL STORAGE AREA FROM
WHICH "HOT" DRUMS WERE RETRIEVED
S.E. PERIMETER ROAD
N35500
EXTENSIVE Pu AND U INFILTRATION DUE TO
903 - AREA RUN OFF, ETC
N35000

MAP 12.



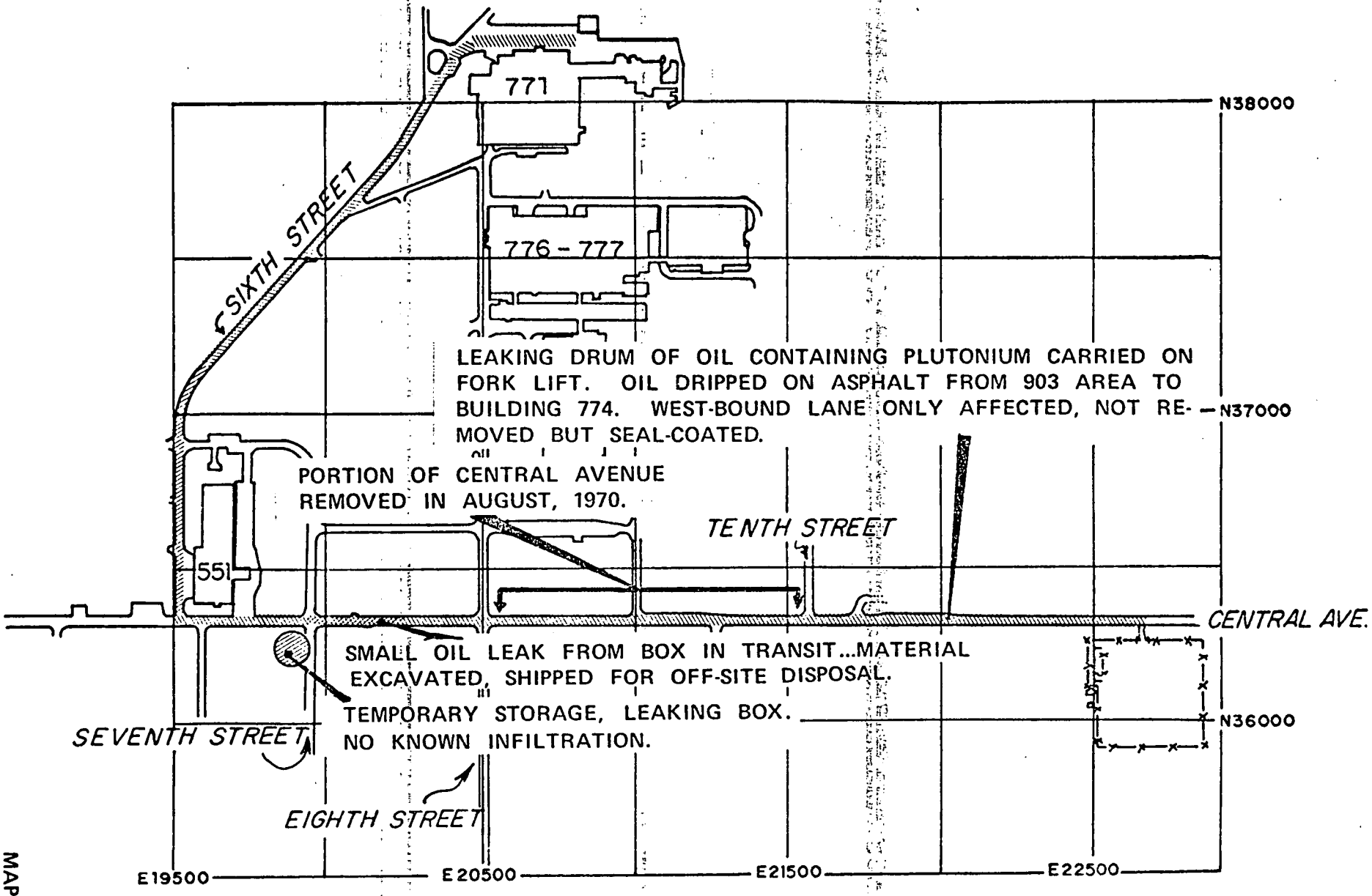
AMERICIUM CONCENTRATIONS (μ Ci/M^2) DETECTED BY FIDLER SURVEY. MULTIPLY NOTED CONCENTRATIONS BY 10^4 TO OBTAIN APPROXIMATE PLUTONIUM CONCENTRATIONS IN mCi/km^2 OR BY 10^1 TO OBTAIN ~μCi/M^2.

MAP 12A.

DRAFT

Map 13 (Roadways)

Incidents involving radioactive infiltration of roadways have been noted. In May 1965, a box containing radioactive waste from Building 776 was moved to the Storage Area near Building 663. Intermittent leakage from that box affected a strip of asphalt about 18 inches wide which was removed from the roadway. The box was stored on plastic sheeting (at Seventh and Central) until removal could be effected. No known infiltration resulted from that storage. In June 1968, a leaking drum in transit from the 903 Area to Building 774 resulted in approximately 140,000 dpm/100 cm^2 on the west bound lane of Central Avenue to and along Sixth Avenue. The entire affected roadway was seal-coated. Some low-level material was spread to the ditch on the west side of Central Avenue. In August 1970, one section of the roadway between Eighth and Tenth Streets was removed and placed in the previously described asphalt dump.



ROADWAYS OF CONCERN.

MAP 13.

Map 14 (Process Waste Lines)

Map 14 details the process waste system at Rocky Flats, tankage, and possible major materials present in those tanks.

In an effort to reduce corrosion, original process waste lines had a saran-lined inner pipe enclosed in a protective clay tile pipe. This saran lining was very susceptible to leakage. Leaks were noted in 1952 and by 1956 most of the original pipe had been replaced with stainless steel. To date, all but about 600 feet of this line has been replaced. The remaining section was thoroughly tested in 1971 and was not leaking.

An exhaustive leak-test survey was conducted in 1971 by an off-site contractor. This leak test was conducted under pressure and disclosed several minor leaks, mostly in low-pressure (essentially gravity-flow) lines. Repairs were started immediately. Attempts were made to repair the higher pressure leaks in place. When these attempts failed, an alternate line was installed. The low leak-rate detected around joints in the gravity flow line is to be expected since this type line is not designed to operate under pressure. Lines have been observed under operational pressures and no leakage observed.

With the exception of Building 559 and between Buildings 776 and 774 as noted below, no radioactive infiltration has been detected outside the lines even in the vicinity of the leaks, but some chemical infiltration, particularly nitrate solutions, is probable. These areas are noted as "areas of concern" on Map 14A primarily in the interests of conservatism. As pipelines have been replaced, soils and liquids have been monitored and, with the noted exceptions, have not resulted in detectable concentrations. However, extremely low-level radioactive and chemical infiltration must be presumed.

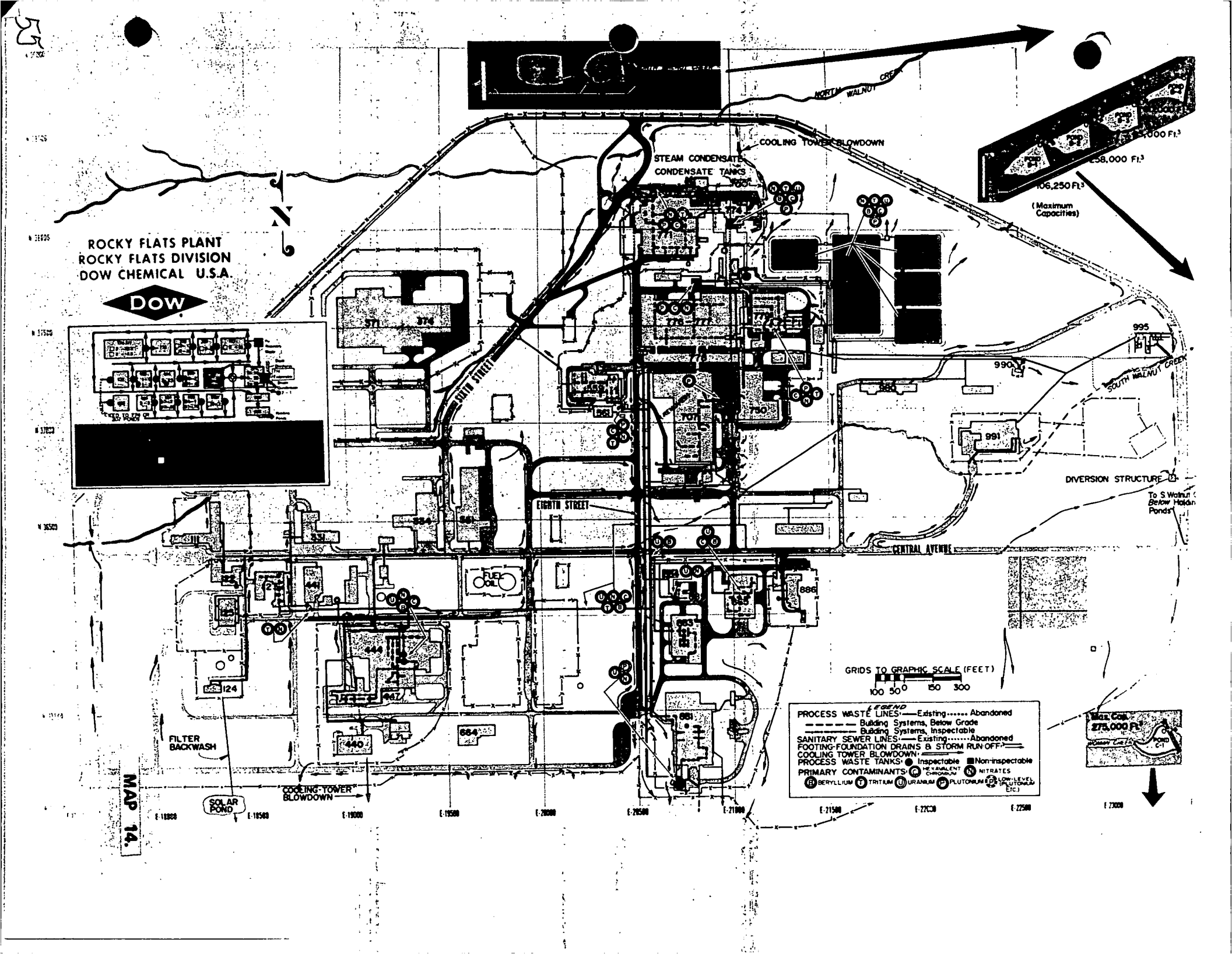
Process waste lines between Buildings 776-777, 779, and 774 and between Buildings 771 and 774 have broken and leaked several times. Valve

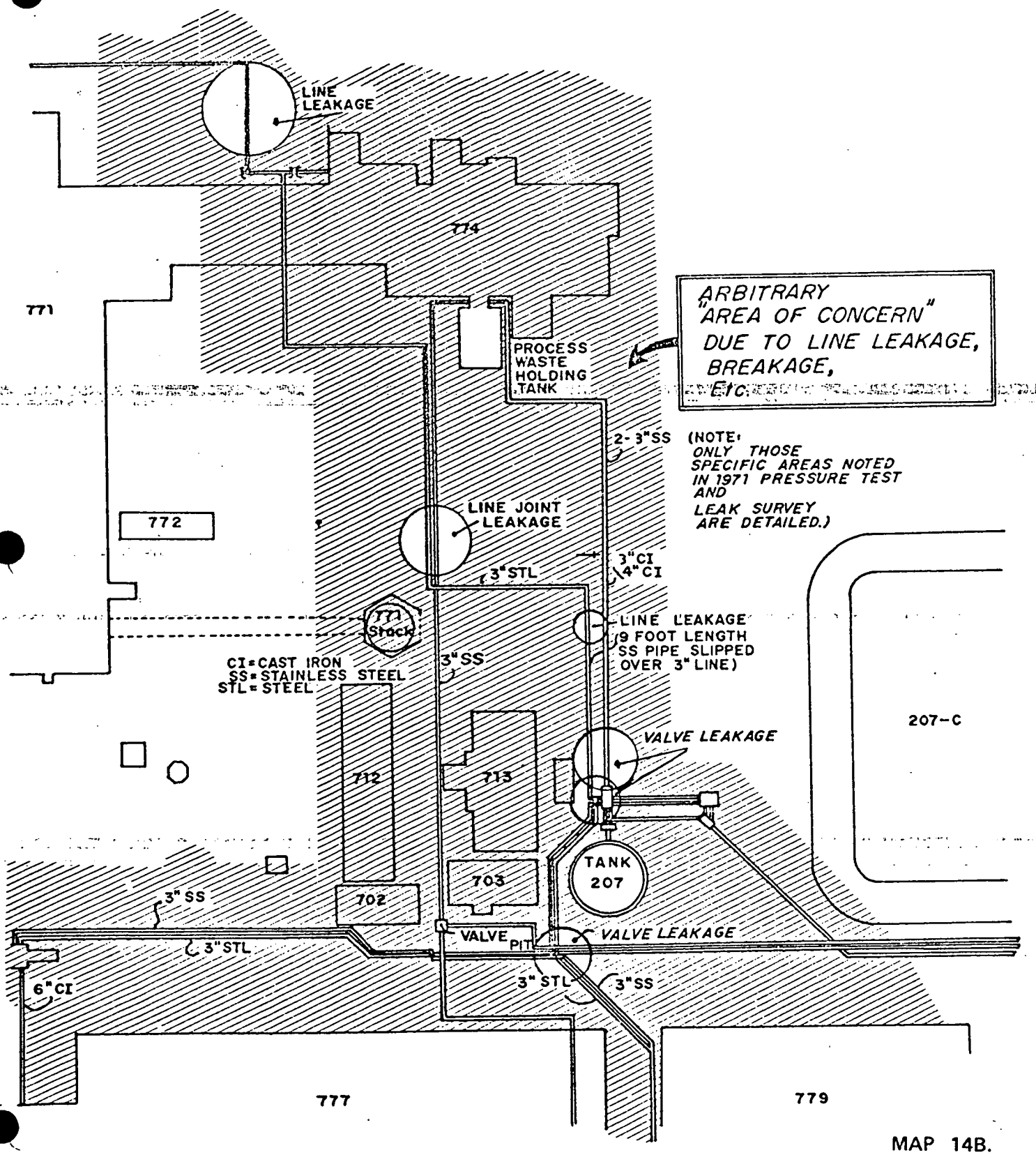
leakage has occurred in the valve pit near waste storage tank 207. Although noted incidents in this area have resulted in clean up (soil removal), residual infiltration is a surety. Thus the entire area from Buildings 776-777 and 779 Complex to Building 774 should be considered an area of concern as shown on Map 14B.

Building 559, a Service Laboratory Facility commissioned in 1968, was originally built with Pyrex® glass waste lines. Less than one year later, a break was discovered in the line from the building to the pump house. Several hundred square feet of infiltrated soil was removed as radioactive waste as a result of the leakage. This same type of line is buried beneath Building 559. In 1972, the south half of this two section line was discovered to be leaking. A PVC pipe bypass was installed. Vertical core sections taken under the building confirm some infiltration directly under the pipeline (approximately 250 dpm/g). Core samples taken outside the building, however, did not detect measurable quantities, indicating that any infiltration is contained beneath the building proper.

The remaining waste lines in Building 559 were static-leak tested following the bypass installation. Current plans call for yearly static-test to prevent recurrence.

Abandoned process waste lines under Building 707 (removed), under the new Filter Plenum for Building 779 (removed), and at the original outfall near Building 990 (still in place) as well as smaller sections elsewhere (i.e., west of Building 771) should be noted. Although not considered as sources for further contributions, some soil has been infiltrated in the immediate vicinity of the lines or original locations.


ROCKY FLATS PLANT
ROCKY FLATS DIVISION
DOW CHEMICAL U.S.A.
DOW
NORTH WALNUT CREEK
COOLING TOWER BLOWDOWN
STEAM CONDENSATE
CONDENSATE TANKS
106,250 Ft.³
(Maximum Capacities)
SOUTH STREET
EIGHTH STREET
CENTRAL AVENUE
SOUTH WALNUT CREEK
DIVERSION STRUCTURE
To S Walnut Below Holdin Ponds
FILTER BACKWASH
SOLAR POND
"COOLING-TOWER" BLOWDOWN
GRIDS TO GRAPHIC SCALE (FEET)
100 50 0 150 300
LEGEND
PROCESS WASTE LINES — Existing ..... Abandoned
Building Systems, Below Grade
Building Systems, Inspectable
SANITARY SEWER LINES — Existing ..... Abandoned
FOOTING-FOUNDATION DRAINS & STORM RUN-OFF
COOLING TOWER BLOWDOWN
PROCESS WASTE TANKS: Inspectable Non-inspectable
PRIMARY CONTAMINANTS: HEXAVALENT CHROMIUM, NITRATES
BERYLLIUM, TRITIUM, URANIUM, PLUTONIUM, LOW-LEVEL (PLUTONIUM ETC.)
Max. Cap. 275,000 Ft.³
MAP 14.


LINE LEAKAGE
774
771
PROCESS WASTE HOLDING TANK
ARBITRARY "AREA OF CONCERN" DUE TO LINE LEAKAGE, BREAKAGE, ETC.
2-3"SS
(NOTE: ONLY THOSE SPECIFIC AREAS NOTED IN 1971 PRESSURE TEST AND LEAK SURVEY ARE DETAILED.)
772
LINE JOINT LEAKAGE
3"STL
3"CI
4"CI
771 Stack
LINE LEAKAGE (9 FOOT LENGTH SS PIPE SLIPPED OVER 3" LINE)
CI=CAST IRON
SS=STAINLESS STEEL
STL=STEEL
3"SS
207-C
VALVE LEAKAGE
712
713
TANK 207
703
702
3"SS
3"STL
VALVE PIT
VALVE LEAKAGE
6"CI
3"STL
3"SS
777
779

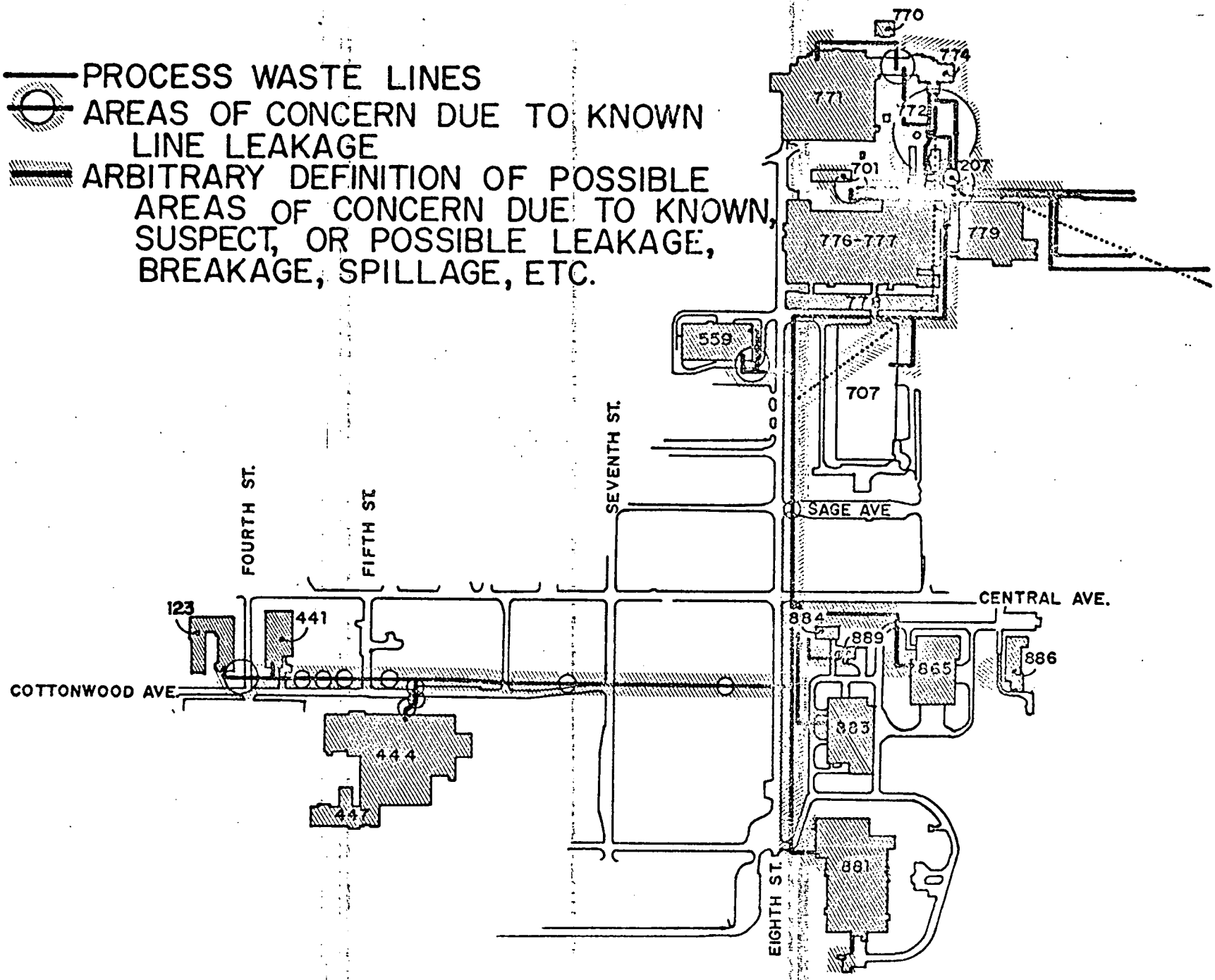
MAP 14B.

57

PROCESS WASTE LINES

AREAS OF CONCERN DUE TO KNOWN LINE LEAKAGE

ARBITRARY DEFINITION OF POSSIBLE AREAS OF CONCERN DUE TO KNOWN, SUSPECT, OR POSSIBLE LEAKAGE, BREAKAGE, SPILLAGE, ETC.



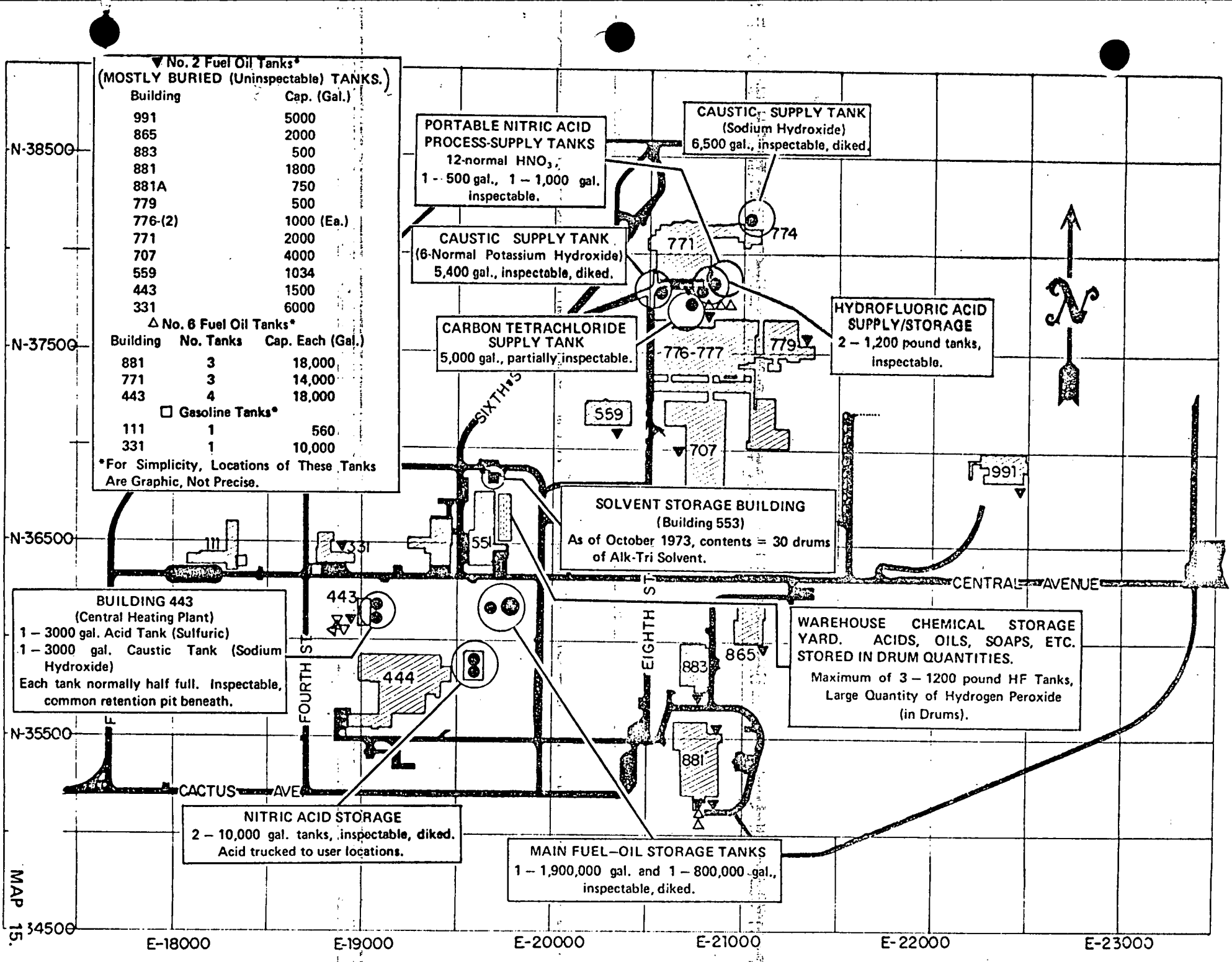
MAP 14A.

DRAFT

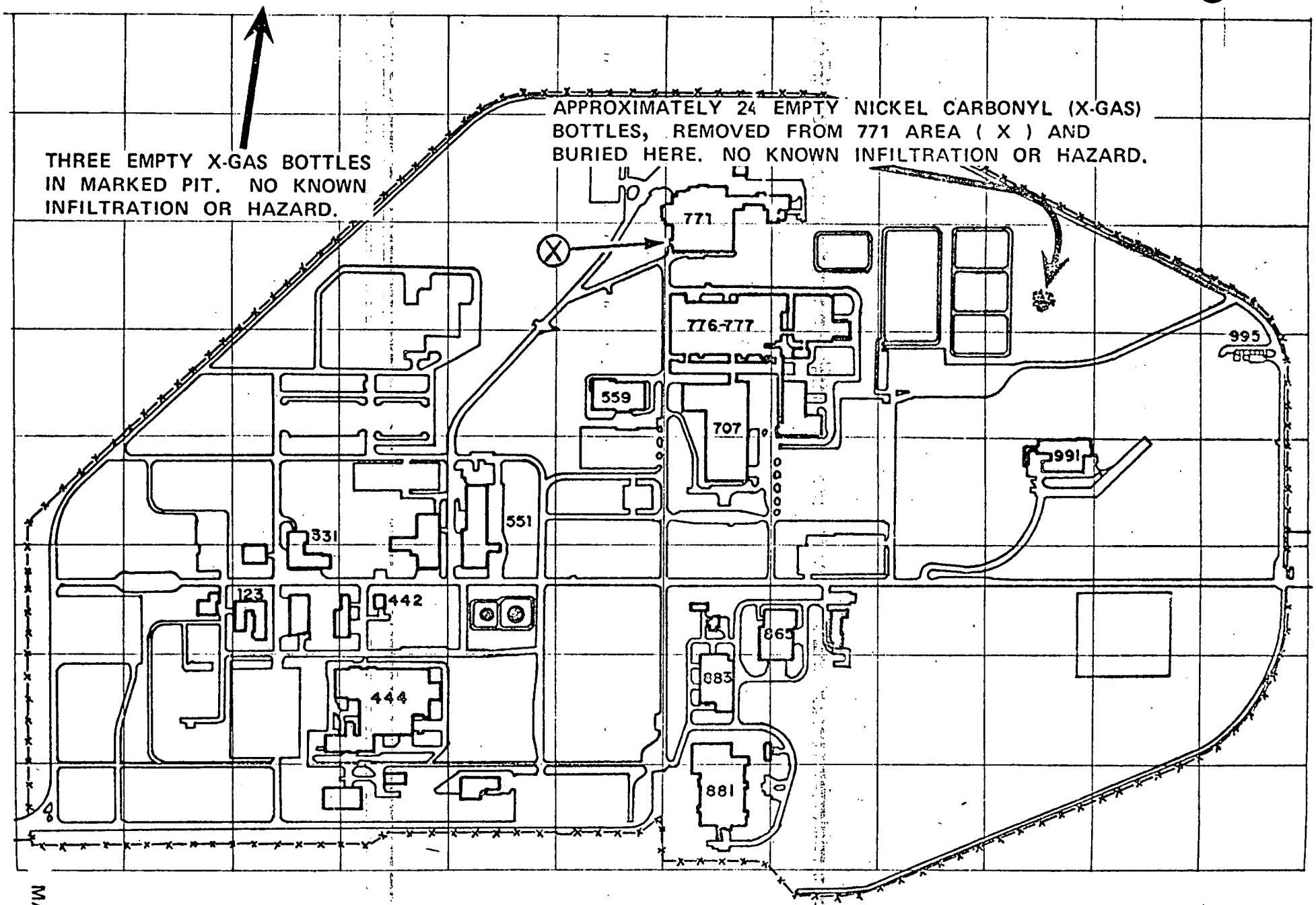
Map 15 (Other Areas)

In addition to the noted areas, some potential for minor chemical infiltration exists in the vicinity of various storage and holding tanks (Map 15). This potential is, in most cases, extremely slight, particularly in those locations where tanks are diked. In the past, before diking was installed, minor spills have occurred and have been discussed in conjunction with the sectional maps.

Map 15A shows the approximate location where empty bottles of nickel carbonyl were buried after the nickel carbonyl was destroyed. The gas was destroyed by burning (during the 1957 fire in Building 771 or when ready for discard). Explosive charges were used to destructively vent the cylinders and ignite any residual gas. No known infiltration or affective residues were generated during these operations or as a result of the burials.


▼ No. 2 Fuel Oil Tanks*
(MOSTLY BURIED (Uninspectable) TANKS.)
Building Cap. (Gal.)
991 5000
865 2000
883 500
881 1800
881A 750
779 500
776-(2) 1000 (Ea.)
771 2000
707 4000
559 1034
443 1500
331 6000
△ No. 6 Fuel Oil Tanks*
Building No. Tanks Cap. Each (Gal.)
881 3 18,000
771 3 14,000
443 4 18,000
☐ Gasoline Tanks*
111 1 560
331 1 10,000
*For Simplicity, Locations of These Tanks Are Graphic, Not Precise.
PORTABLE NITRIC ACID PROCESS-SUPPLY TANKS
12-normal HNO3,
1 - 500 gal., 1 – 1,000 gal.
inspectable.
CAUSTIC SUPPLY TANK
(Sodium Hydroxide)
6,500 gal., inspectable, diked.
CAUSTIC SUPPLY TANK
(6-Normal Potassium Hydroxide)
5,400 gal., inspectable, diked.
CARBON TETRACHLORIDE SUPPLY TANK
5,000 gal., partially inspectable.
HYDROFLUORIC ACID SUPPLY/STORAGE
2 – 1,200 pound tanks, inspectable.
SOLVENT STORAGE BUILDING
(Building 553)
As of October 1973, contents = 30 drums of Alk-Tri Solvent.
BUILDING 443
(Central Heating Plant)
1 – 3000 gal. Acid Tank (Sulfuric)
1 – 3000 gal. Caustic Tank (Sodium Hydroxide)
Each tank normally half full. Inspectable, common retention pit beneath.
WAREHOUSE CHEMICAL STORAGE YARD. ACIDS, OILS, SOAPS, ETC. STORED IN DRUM QUANTITIES.
Maximum of 3 – 1200 pound HF Tanks, Large Quantity of Hydrogen Peroxide (in Drums).
NITRIC ACID STORAGE
2 – 10,000 gal. tanks, inspectable, diked.
Acid trucked to user locations.
MAIN FUEL-OIL STORAGE TANKS
1 – 1,900,000 gal. and 1 – 800,000 gal., inspectable, diked.
N-38500
N-37500
N-36500
N-35500
N-34500
E-18000
E-19000
E-20000
E-21000
E-22000
E-23000
SIXTH ST
FOURTH ST
EIGHTH ST
CENTRAL AVENUE
CACTUS AVE
111
331
551
559
707
771
774
776-777
779
865
881
883
991
443
444

MAP 15


THREE EMPTY X-GAS BOTTLES IN MARKED PIT. NO KNOWN INFILTRATION OR HAZARD.
APPROXIMATELY 24 EMPTY NICKEL CARBONYL (X-GAS) BOTTLES, REMOVED FROM 771 AREA (X) AND BURIED HERE. NO KNOWN INFILTRATION OR HAZARD.
771
776-777
995
559
707
991
331
551
123
442
865
883
444
881

MAP 15A.

III. "CONTAMINATED"

The word "contaminated" has become common to the vocabulary of groups and individuals involved or interested in environmental sciences and affairs. This is particularly true with regard to nuclear energy; however, there is no realistic or practical definition of "contaminated." Webster's New Collegiate Dictionary (copyrighted 1969) defines "contaminate" as:

> "1. To soil, stain, or infect by contact or association.
> 2. To make unfit for use by introduction of unwholesome or undesirable elements."

U. S. Department of Health, Education, and Welfare Radiological Health Handbook (revised edition January 1970) defines "radioactive contamination" as:

> "Deposition of radioactive material in any place where it is not desired, particularly where its presence may be harmful. The harm may be in vitiating an experiment or a procedure or in actually being a source of danger to personnel."

A more appropriate definition would be to relate contamination levels to the intended use or application of the material, area, etc. Earlier editions of Webster's New Collegiate Dictionary (copyrighted 1961) made an attempt in this direction defining "contaminate" as follows:

> "1. To soil, stain, or corrupt by contact; to pollute.
> 2. To render (water otherwise satisfactory) unfit for a specified use, as by the introduction of bacteria, sewage, etc."

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It is obvious that even this definition is inadequate and it becomes understandable why most people use "contaminated" in an apprehensive manner and to achieve or express a state of concern.

Our society has established and accepted a system which makes it possible to live with "contaminated." The system consists of groups of recognized experts who examine factual and theoretical data to establish and recommend concentration limits or guide values which are not expected to result in irreparable damage or insult to man or his environment. These groups of experts have been assigned names such as International Commission on Radiological Protection (ICRP), National Council on Radiation Protection (NCRP), Federal Radiation Council (FRC), Council on Environmental Quality, and others. It is true that the concentration limits or guide values recommended by these groups are challenged by other individuals and groups but the system and concentration philosophy are generally accepted.

The U. S. Atomic Energy Commission has incorporated recommendations of these groups into AEC Manual Chapters 0510, "Prevention, Control, and Abatement of Air and Water Pollution," and 0524, "Standards for Radiation Protection." Concentration values have been recommended and accepted for air and water. However, due to wide variations in many factors related to resuspension and other physical and chemical properties, no recommendations or concentration values exist for soil.

The fact that recommendations or values do not exist for soil does not mean that no efforts have been made to establish values or that values have not been established and actually used for specific circumstances. One of the most widely accepted and recent (1968) discussions of radioactivity concentration guides for plutonium in soil was presented by R. L. Kathren, Battelle Northwest, Richland, Washington, entitled "Towards Interim Acceptable Surface Contamination Levels for Environmental PuO_2," BNWL-SA-1510, which is attached as Appendix A. Los Alamos Scientific Laboratory has been commissioned by the Division of Operational Safety of

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[redacted]

the U. S. Atomic Energy Commission to provide an interim or provisional standard for plutonium in soil. J. W. Healy is presently preparing a report entitled "A Proposed Interim Standard for Plutonium in Soils." A review of the draft and discussions with Mr. Healy indicate no significant differences or variations from the information and conclusions presented by Mr. Kathren.

Since man does not consume soil, the hazard to man from "contaminated" soil must come from resuspension of the material into the air which man inhales, transfer of the material into water which man drinks, uptake of the material by plants or animals which man eats, absorption of the material through man's skin, or introduction through the broken skin of man. An additional hazard may result when soil is "contaminated" with radioactive materials which emit beta particles, x-rays, or gamma rays which penetrate man's skin in excess of the amounts set forth in AEC Manual Chapter 0524; however, with the exception of radiographic sources, these types of radioactive materials are not handled at Rocky Flats.

With the preceding paragraph in mind, it is possible to recommend a definition of "contaminated" soil in terms of risk or hazard as related to air and water concentration values. It must be stressed that the following recommended definition is not an attempt to imply that areas of potential concern do not exist on the Rocky Flats Plant site but is one which has been used and should continue in use until such time that one of the official groups of experts recommends concentration values for soil and the U. S. Atomic Energy Commission incorporates the recommendations into the AEC Manual.

Contaminated soil will be deemed to exist whenever monitoring of air or water indicates concentration values in excess of the values set forth in the AEC Manual.

For those materials which are not included in the AEC Manual, the values set forth by other officially recognized agencies

will be used. When two or more concentration values for the same material are specified by different agencies, the most restrictive value will apply.

Note

By specifying monitoring of air or water this definition excludes the plutonium in soil concentration value of 2.0 disintegrations per minute per gram of dry soil or square centimeter of surface area which was adopted by the Colorado State Board of Health on March 21, 1973, as the level above which utilization of special techniques of construction are required.

This definition is generally accepted and used for most materials and will be used in the preparation of recommendations regarding actions, cost estimates, and schedules related to chemical "contamination." However, it is recognized that consideration must also be given to possible decommissioning of the plant and social, political, psychological, or other factors when dealing with the subject of radioactive "contamination" in soil. Therefore, the recommendations will also include consideration of the following ranges of plutonium in soil:

Case	Greater Than $\mu Ci/m^2$	mCi/km^2	$d/m/100\ cm^2$	d/m/g*
I	Not limited by concentration considerations.			
	A. 903 and nearby area			
	B. Projections of area affected by 903 Area (Based on Computer Derived Contours)			
	C. Burial Sites			
II	0.01	10	220	2
III	0.04	40	880	9
IV	0.10	100	2,200	22
V	0.40	400	8,800	88
VI	2.0	2,000	44,000	440
VII	4.0	4,000	88,000	880

*Assumes a soil density of 1 gram per cubic centimeter and a soil sample depth of 1 centimeter.

Note

Cases II through VII are based on projections of actual sample results using the Austin Grid.

A detailed discussion of each of the above cases is as follows:

Case I - Not limited by concentration considerations

A. 903 and Nearby Area (Maps 12 and 12A)

The 146,000 square feet under the asphalt pad and approximately 223,000 square feet of nearby area primarily east

of the asphalt pad require special consideration. Ten inches of fill dirt was applied to the 903 Area prior to installation of the asphalt pad and the nearby area was later covered with 4 inches of fill dirt. There are also small areas under the asphalt pad where containment operations prior to covering the area with fill dirt involved covering the area with as much as 16 inches of dirt. It is assumed that evcavation of this 369,000 square foot area would not involve the asphalt pad but would involve all of the fill dirt as well as the original soil.

The nearby area to the southeast of the asphalt pad involves approximately 120,000 square feet but there is no fill dirt in this area. This area does include the lithium destruction areas which if excavation were carried out should be included in the operation.

Based on these facts and assumptions, it is estimated that excavation of the lithium destruction area and the entire remaining area to a depth of 3 inches below the original surface would involve a total of 500,000 cubic feet.

B. Projections of Area Affected by 903 Area (Based on Computer Derived Contours)

Computer derived contours of plutonium contributions from the 903 Area are presented in Map 16. (Units are AEC prescribed $\mu Ci/m^2$.) These contours are based on the evaluation of over 300 soil sample analyses as of April 1972, assuming a soil density of 1 gram per cubic centimeter. This assumption plus the combining of analytical values from a variety of agencies and

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individuals and the error of assuming large area involvement based on diverse sample results, limits the applicability of these contours to an illustrative, generalized area only. A more realistic evaluation of the nature of the material spread can be obtained by observing actual sample locations and results (Maps 16A and 16B).

The projections are based on the units employed in generating the isopleths (i.e., 0.01, 0.05, 0.50, and greater than 2.0 $\mu Ci/m^2$) and assuming excavation to 3 inches below the original surface plus consideration of the special conditions discussed concerning the 903 and nearby area.

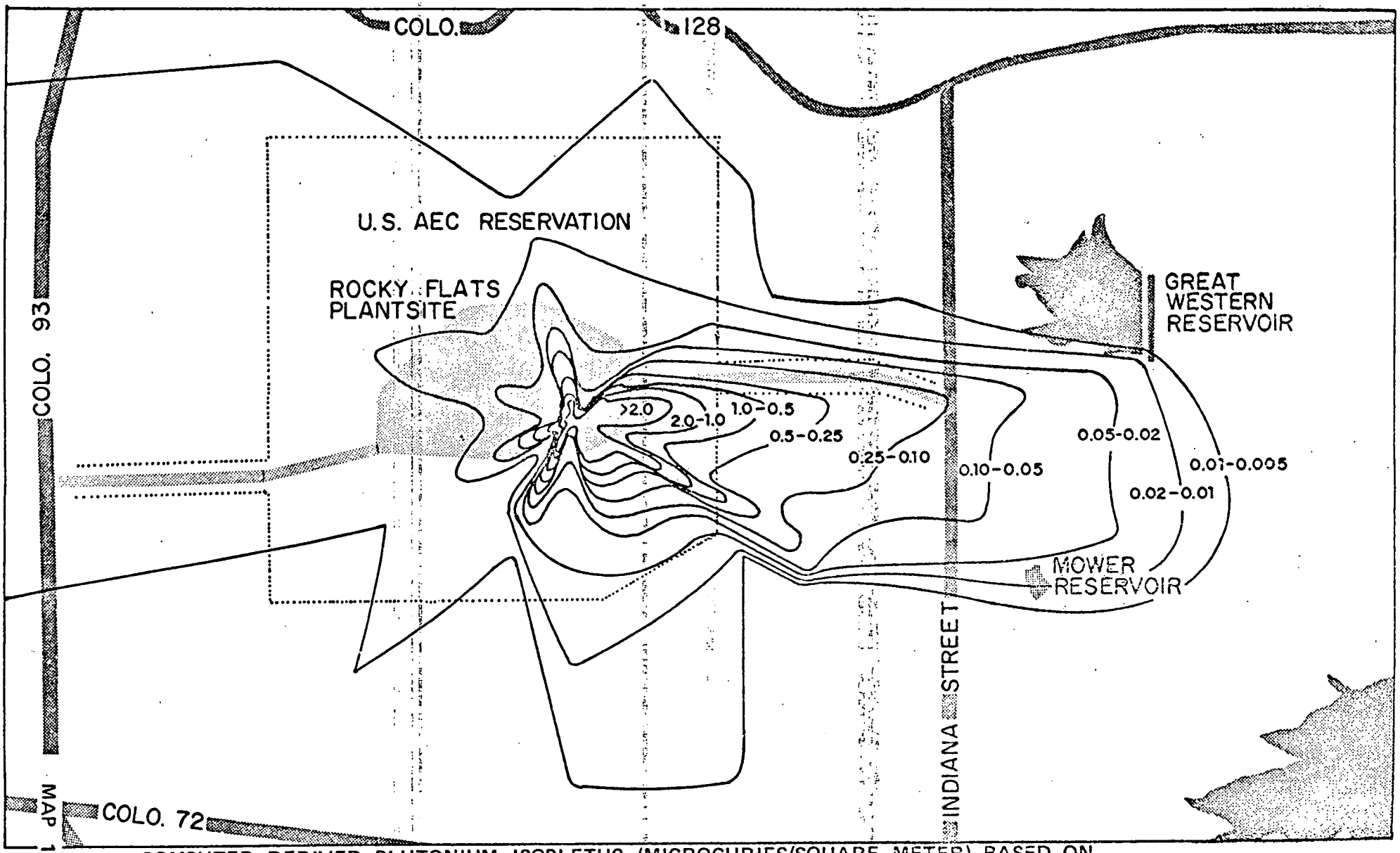
1. Total excavation, estimated total area = 182×10^6 square feet (4,197 acres), volume = 46×10^6 cubic feet. (Case I, Map I)

2. Excavation of all soil greater than 0.01 $\mu Ci/m^2$. Approximate Area = 84.9×10^6 square feet, volume = 21.5×10^6 cubic feet. (Case I, Map II)

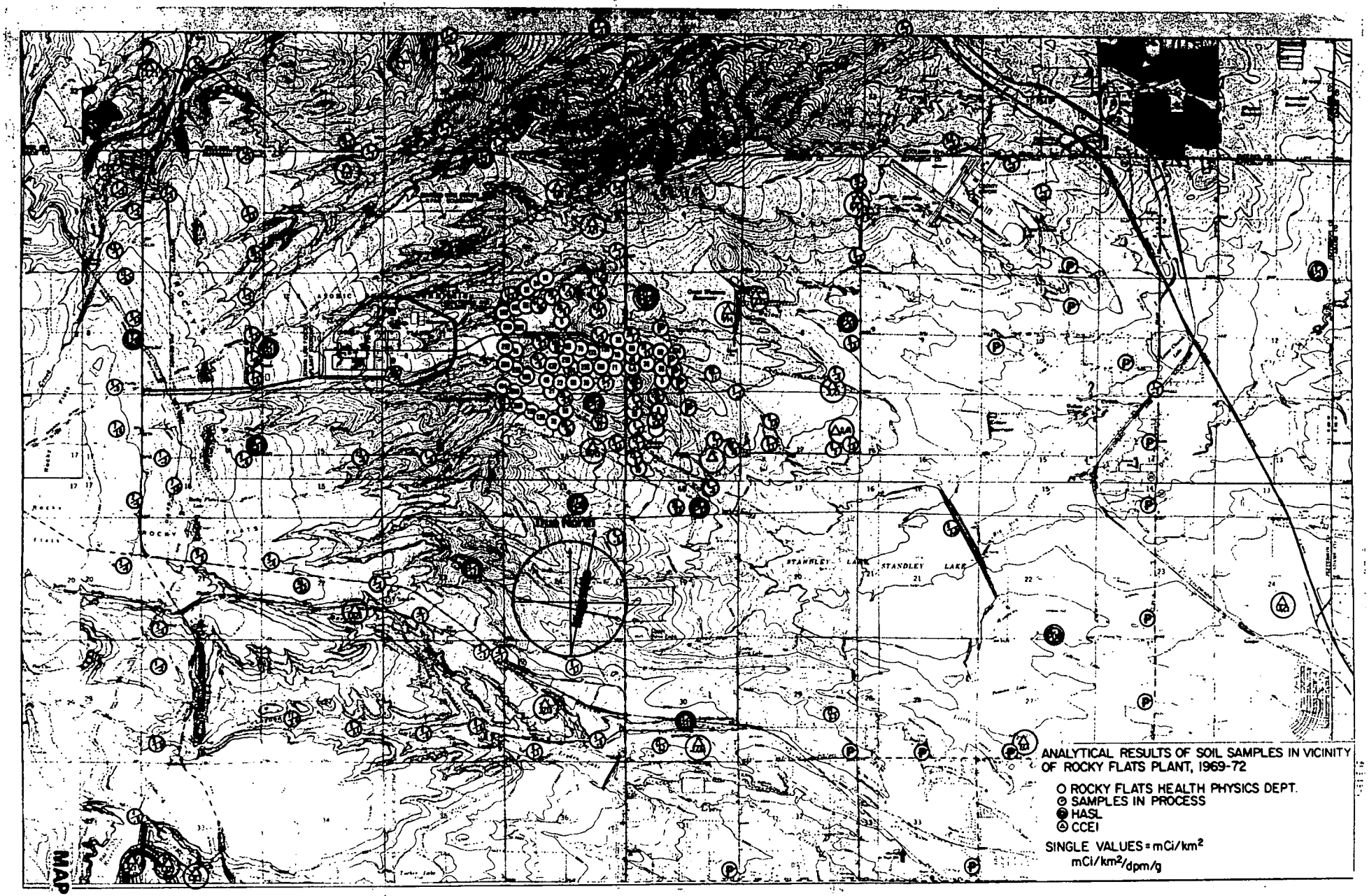
3. Excavation of all soil greater than 0.05 $\mu Ci/m^2$, Approximate Area = 33.2×10^6 square feet, volume = 8.7×10^6 cubic feet. (Case I, Map III)

4. Excavation of all soil greater than 0.5 $\mu Ci/m^2$, Approximate Area = 14.5×10^6 square feet, volume = 4.0×10^6 cubic feet. (Case I, Map IV)

5. Excavation of all soil greater than 2 $\mu Ci/m^2$, Approximate Area = 3.1×10^6 square feet, Approximate volume = 1.2×10^6 cubic feet. (Case I, Map V)



COMPUTER DERIVED PLUTONIUM ISOPLETHS (MICROCURIES/SQUARE METER) BASED ON EVALUATION OF OVER 300 SOIL SAMPLES, ASSUMING A SOIL DENSITY OF 1 GRAM /CC AND COMPATABILITY OF SAMPLES FROM VARIOUS AGENCIES.


ANALYTICAL RESULTS OF SOIL SAMPLES IN VICINITY OF ROCKY FLATS PLANT, 1969-72
O ROCKY FLATS HEALTH PHYSICS DEPT.
SAMPLES IN PROCESS
HASL
CCEI
SINGLE VALUES = mCi/km²
mCi/km²/dpm/g
STANDLEY LAKE
STANDLEY LAKE

MAP 16A

No real evaluation of the potential impact of the 903 Area is possible without reference to possible health and safety involvement of the material. Although no standards for plutonium in soil currently exist, considerable work has been done in this area. Map 17 details computer-derived plutonium in soil contours based on interim acceptable levels proposed by R. L. Kathren in 1968 (see Appendix A). These contours are presented for reference only and are subject to the same limitations previously discussed. They do, however, point out one approach to evaluation of the possible risk which this area represents.

As a further indication of the problems involved with identifying an area as "contaminated", Map 18 indicates some of the values for plutonium in soil found throughout the State of Colorado. Once again the problem of comparing results obtained by different agencies using different sampling techniques and analytical methods confuses the actual picture.

C. Burial Sites (Case I, Map VI)

Excavation of locations, other than the 903 Area, where materials have been intentionally buried, contained, or where release of liquid effluents which contained radioactivity in concentrations less than the established guide value but resulted in the radioactivity accumulating in the soil would involve the following estimated volumes:

1. Oil Burning Pit #1

This area is now located under Building 335 and involves approximately 70 cubic feet of depleted uranium residue.

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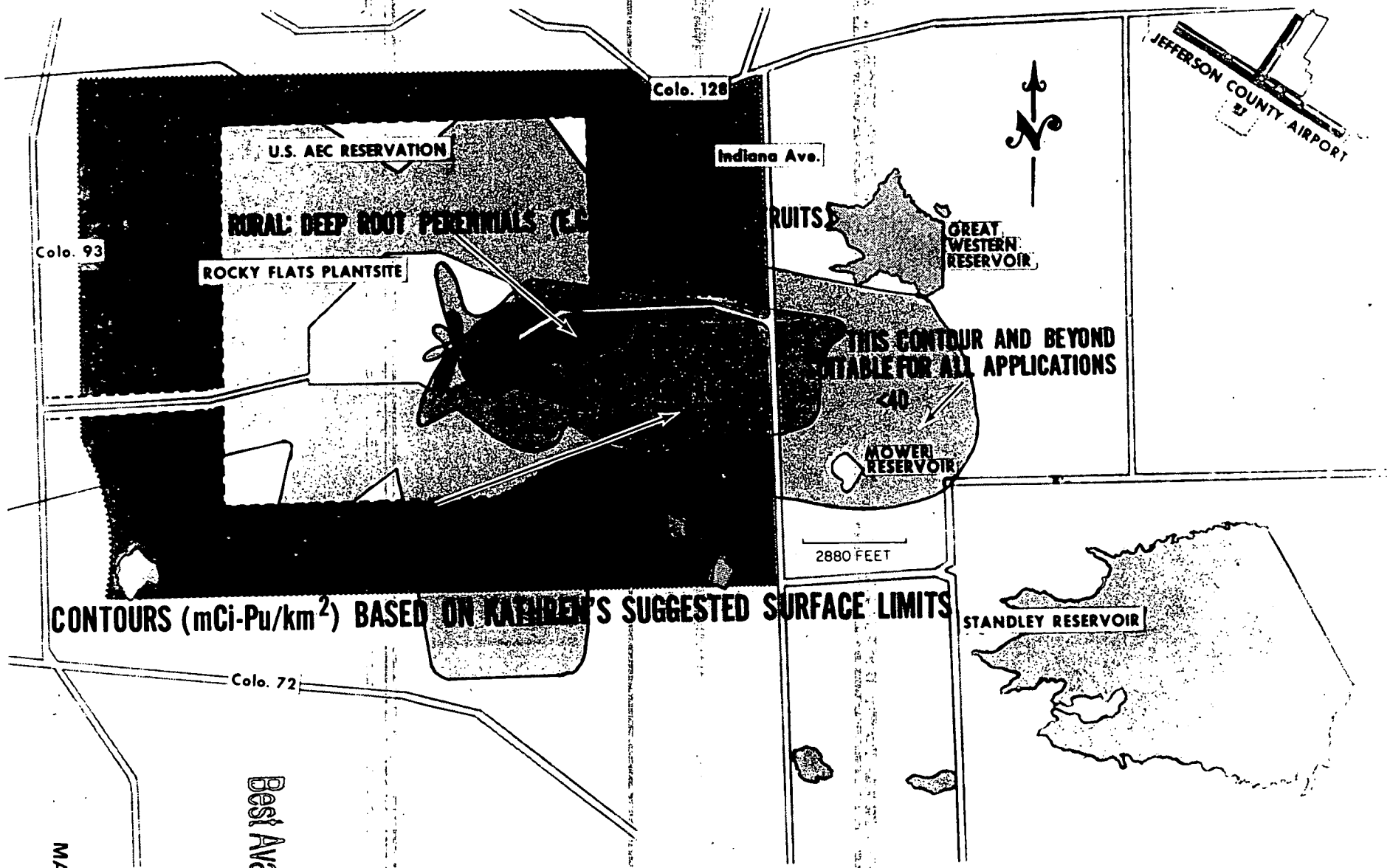
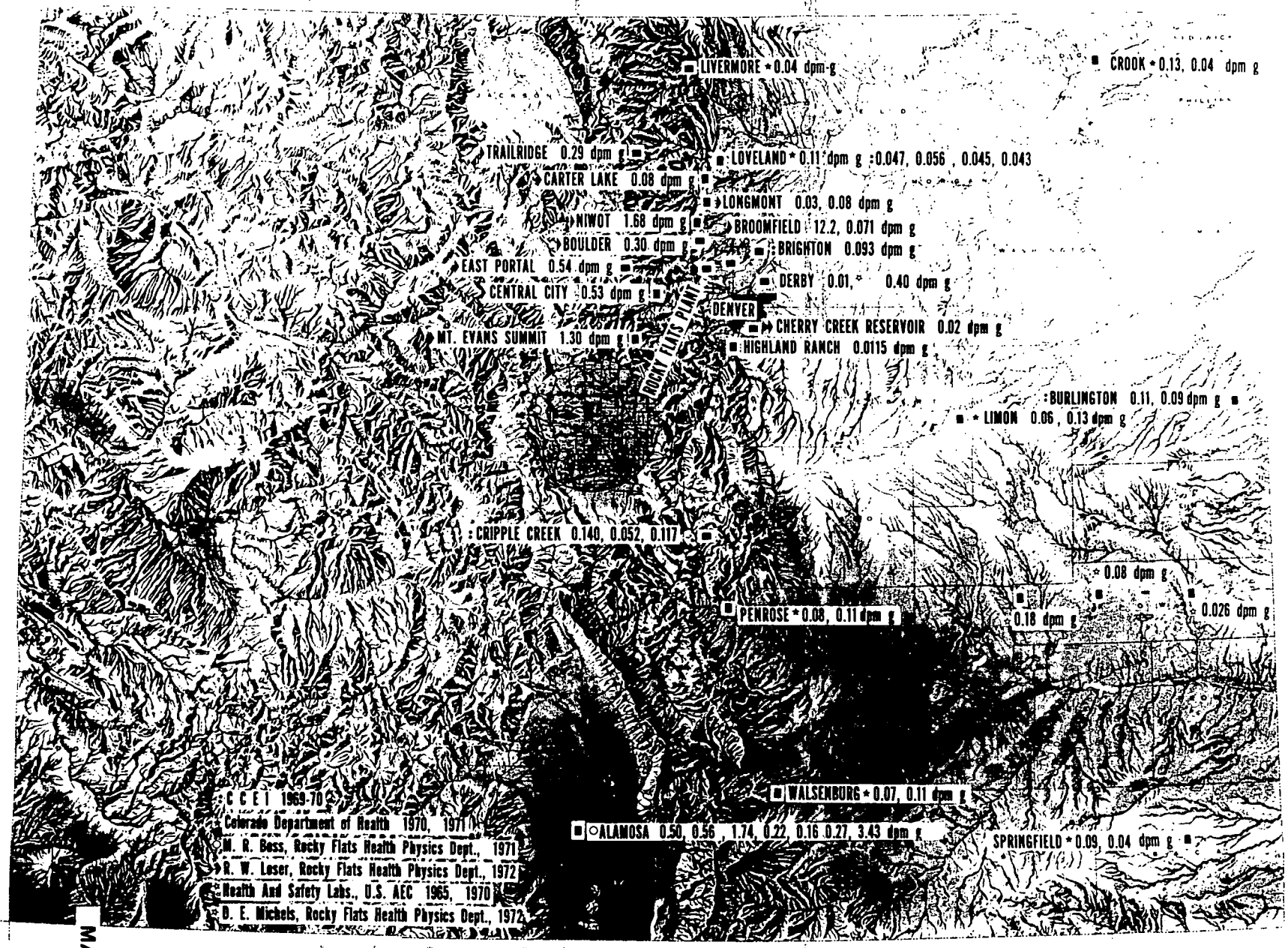


CONTOURS (mCi-Pu/km^2) BASED ON KAHREN'S SUGGESTED SURFACE LIMITS

MAP 17.

STATE OF COLORADO



MAP 18.

2. Oil Burning Pit #2

This area involves approximately 10,000 cubic feet of residue which resulted from the burning of oil containing uranium.

3. Trench T-1

The estimated dimensions of this trench are 15' wide x 200' long x 5' deep. The trench contains approximately 25,000 kg of depleted uranium chips in drums covered with about two feet of fill dirt. Assuming that the top one foot of fill dirt is not involved, excavation would result in 12,000 cubic feet of depleted uranium residue.

4. Trenches T-2 through T-8

Estimated dimensions of these trenches are the same as T-1 (15'x200'x5'). Excavation of these trenches would result in approximately 84,000 cubic feet consisting primarily of domestic sewage sludge containing small quantities of uranium and trace amounts of plutonium, a few flattened drums involving uranium, and some asphalt planking from the 207 ponds which contains uranium and a trace amount of plutonium.

5. Asphalt and Soil Disposal Area

This area contains about 8,000 cubic feet of asphalt and 1,600 cubic feet of soil primarily from the areas near Buildings 774 and 776. There is about two feet of fill dirt between the asphalt and soil and it is

estimated that excavation would involve a total of about 15,000 cubic feet of material with a very low concentration of plutonium.

6. Incinerator Ash Pits I-1 through I-4

Estimated dimensions of these pits are 8' wide x 150' long x 3' deep. The pits contain the ashes from the incinerator. A small amount of depleted uranium is suspected. Excavation would involve approximately 30,000 cubic feet of soil and ashes.

7. Original Sanitary Landfill

Estimated volume of this area is 2×10^6 cubic feet. Excavation would involve this entire volume and about 20 kg of depleted uranium.

8. Current Sanitary Landfill

Estimated present volume of this area is 4×10^6 cubic feet. The area is still in use and the volume is, therefore, increasing each day. Excavation would include approximately 1,000 kg of domestic sewage sludge containing trace amounts of plutonium and a small amount of tritium from a source which at the present is unknown but is the subject of a separate study.

9. South Walnut Creek

The area from the original Building 774 outfall east to and including the B series holding ponds has become involved due to the release of liquid effluents from

Buildings 774 and 995. At the time of release, these effluents were below the established concentration guide values, however, the radioactivity has accumulated in the stream bed and bottoms of the ponds. Excavation would involve an estimated 225,000 cubic feet of sludge containing plutonium and uranium.

10. Other Areas

As previously discussed, excavation of the lithium destruction areas is included in the 903 Area. Excavation of other nonradioactively involved areas such as the oil sludge disposal south of Building 881 and nonradioactive scrap west of Building 559 would result in an estimated 2,000 cubic feet of material.

A summary of the volume of material involved in Case I is presented as Table III.

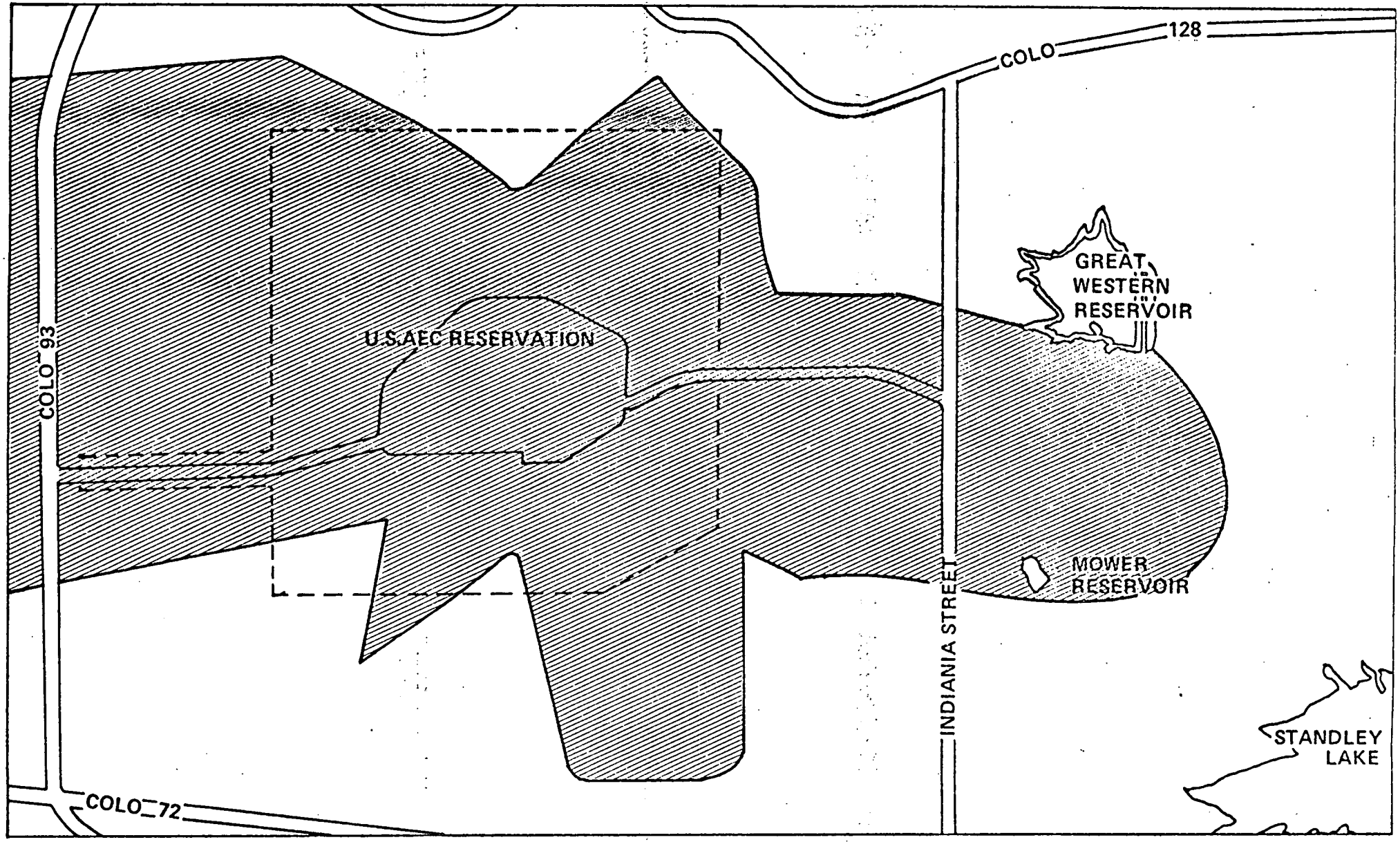
TABLE III

Summary of Volume to be Excavated - Case I

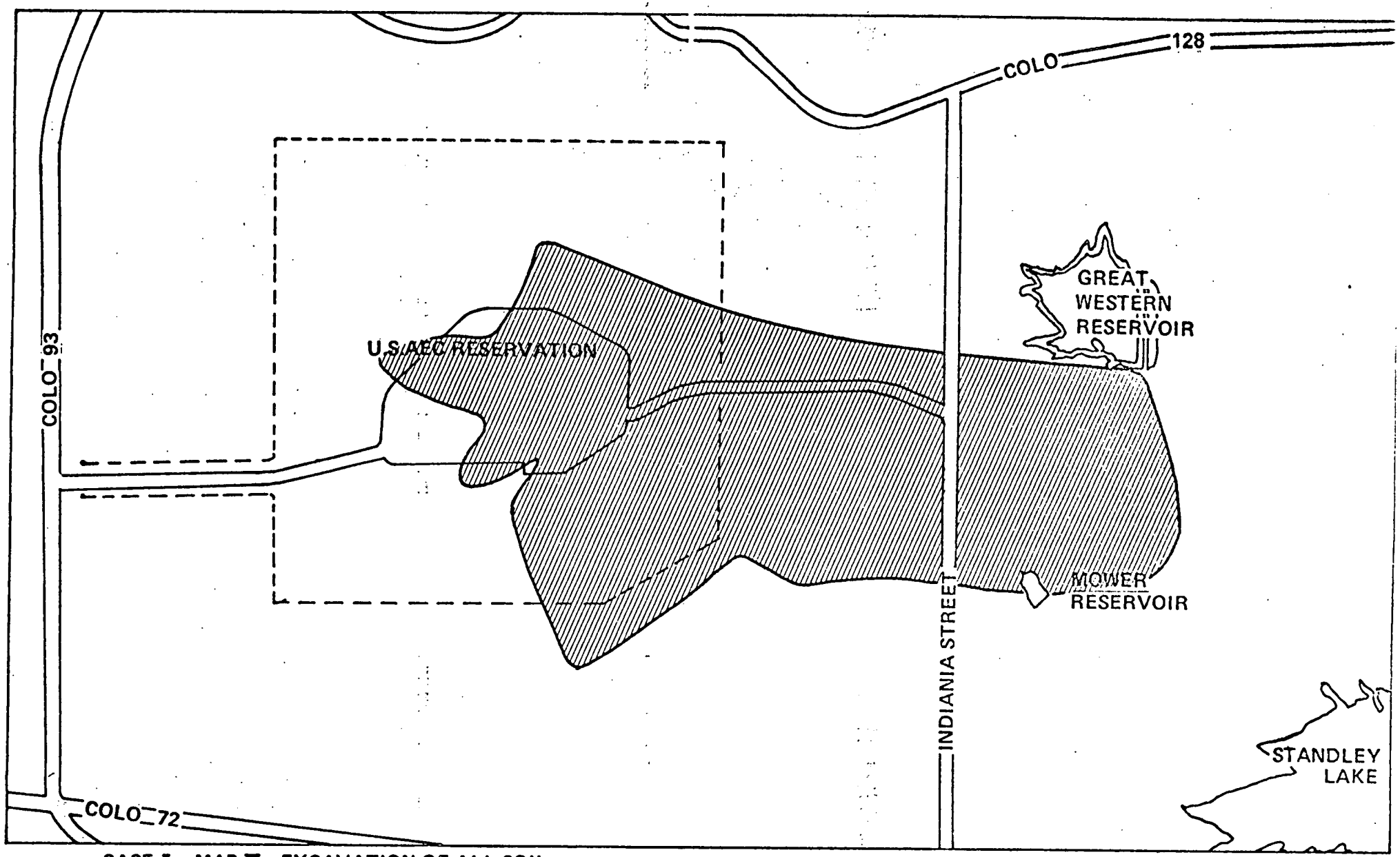
Area	Estimated Total Cubic Feet Involved
A. 903 and Nearby Area	500,000
*B. Projections of Areas Affected by 903 Area, Computer Derived Contours	
1. Total Excavation	46.0×10^6
2. Greater Than 0.01 $\mu Ci/m^2$	21.5×10^6
3. Greater than 0.05 $\mu Ci/m^2$	8.7×10^6
4. Greater than 0.5 $\mu Ci/m^2$	4.0×10^6
5. Greater than 2.0 $\mu Ci/m^2$	1.2×10^6

*Includes allowance for special conditions included in (A).

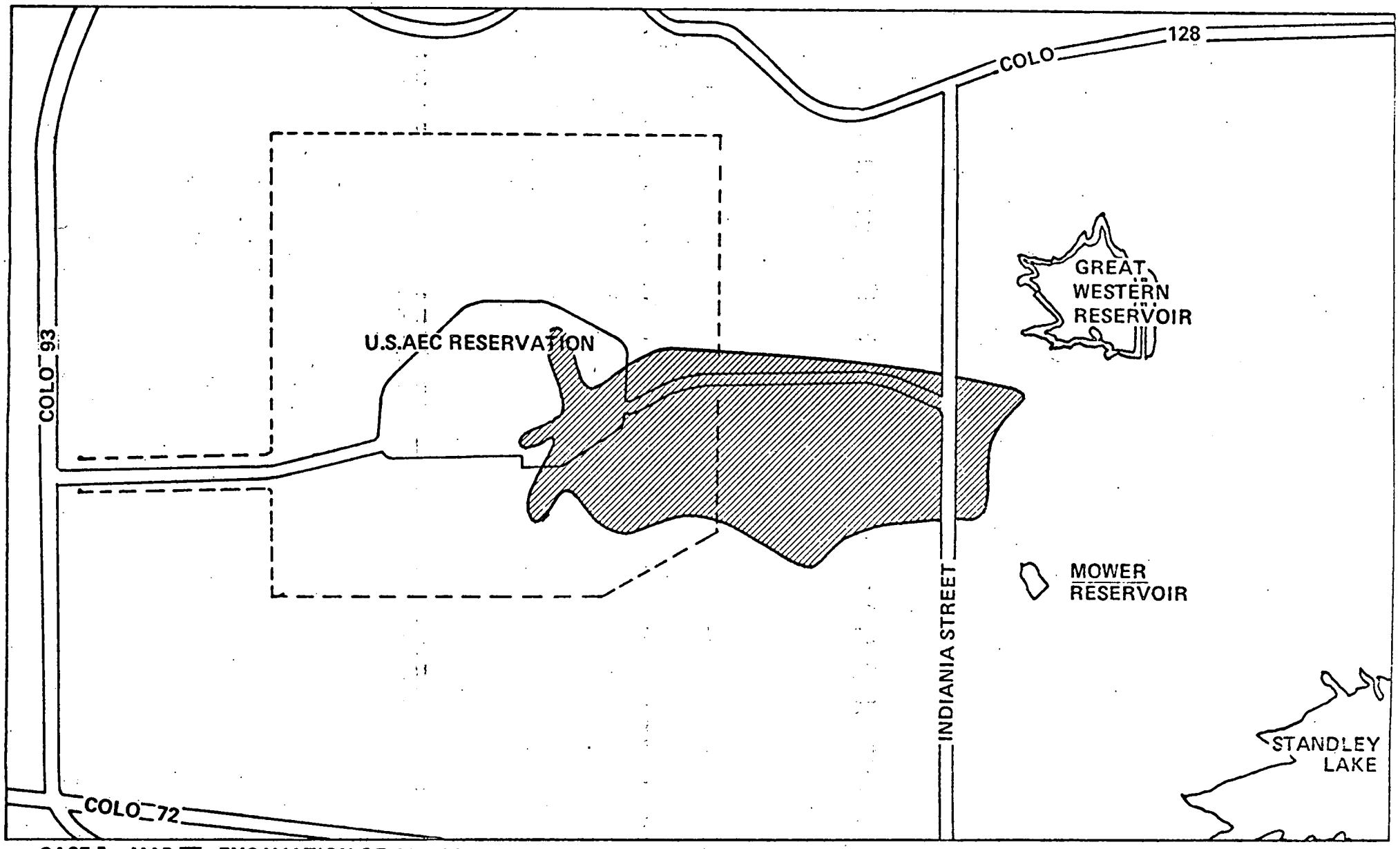
C. Burial Sites	
1. Oil Burning Pit #1	70
2. Oil Burning Pit #2	10,000
3. Trench T-1	12,000
4. Trenches T-2 through T-8	84,000
5. Asphalt and Soil Disposal Area	15,000
6. Incinerator Ash Pits	30,000
7. Original Sanitary Landfill	2×10^6
8. Current Sanitary Landfill	4×10^6
9. South Walnut Creek	225,000
10. Other Areas	2,000
Estimated Total Burial Sites Not Including (A).	6.4×10^6



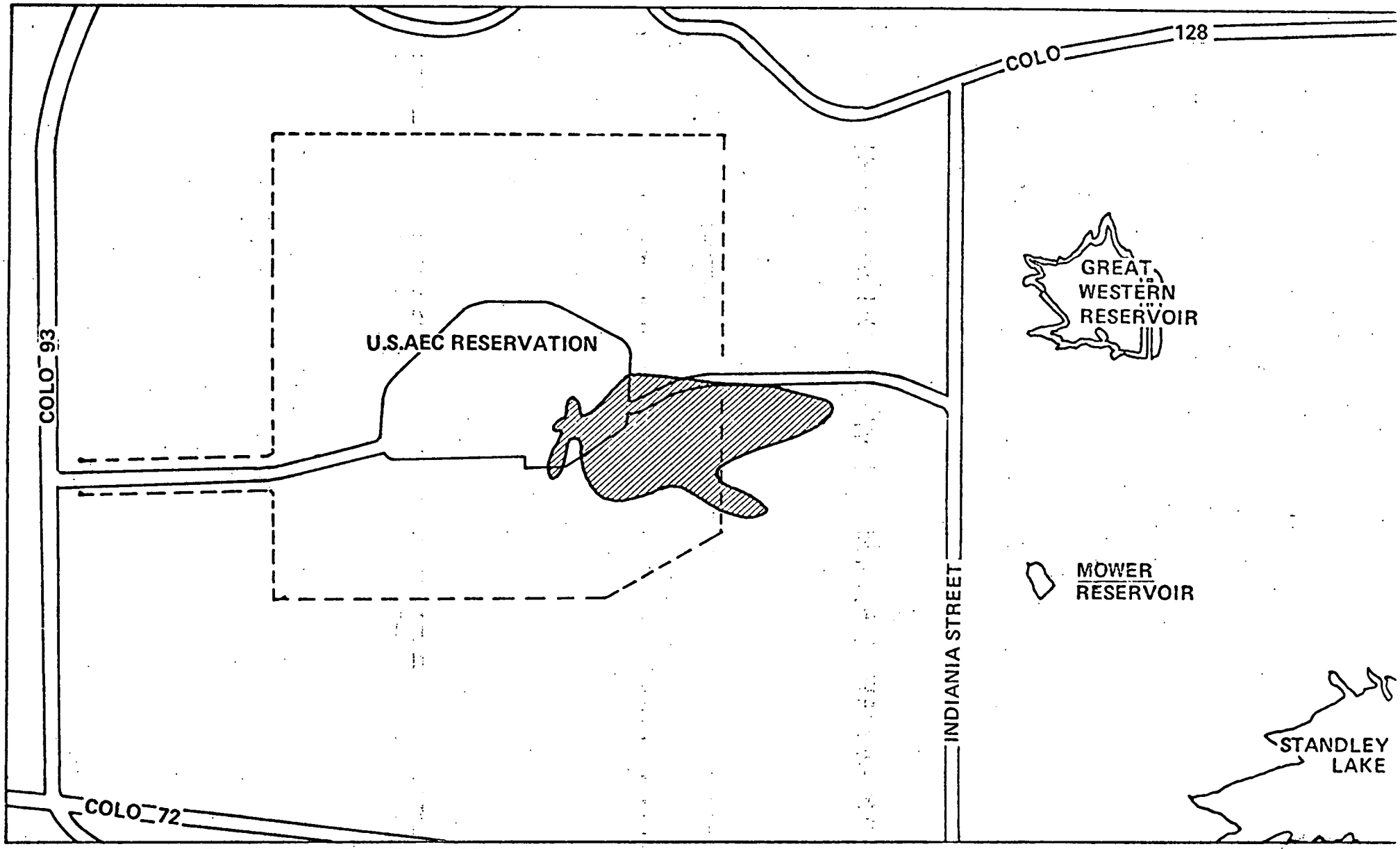
CASE I – MAP I. TOTAL EXCAVATION.



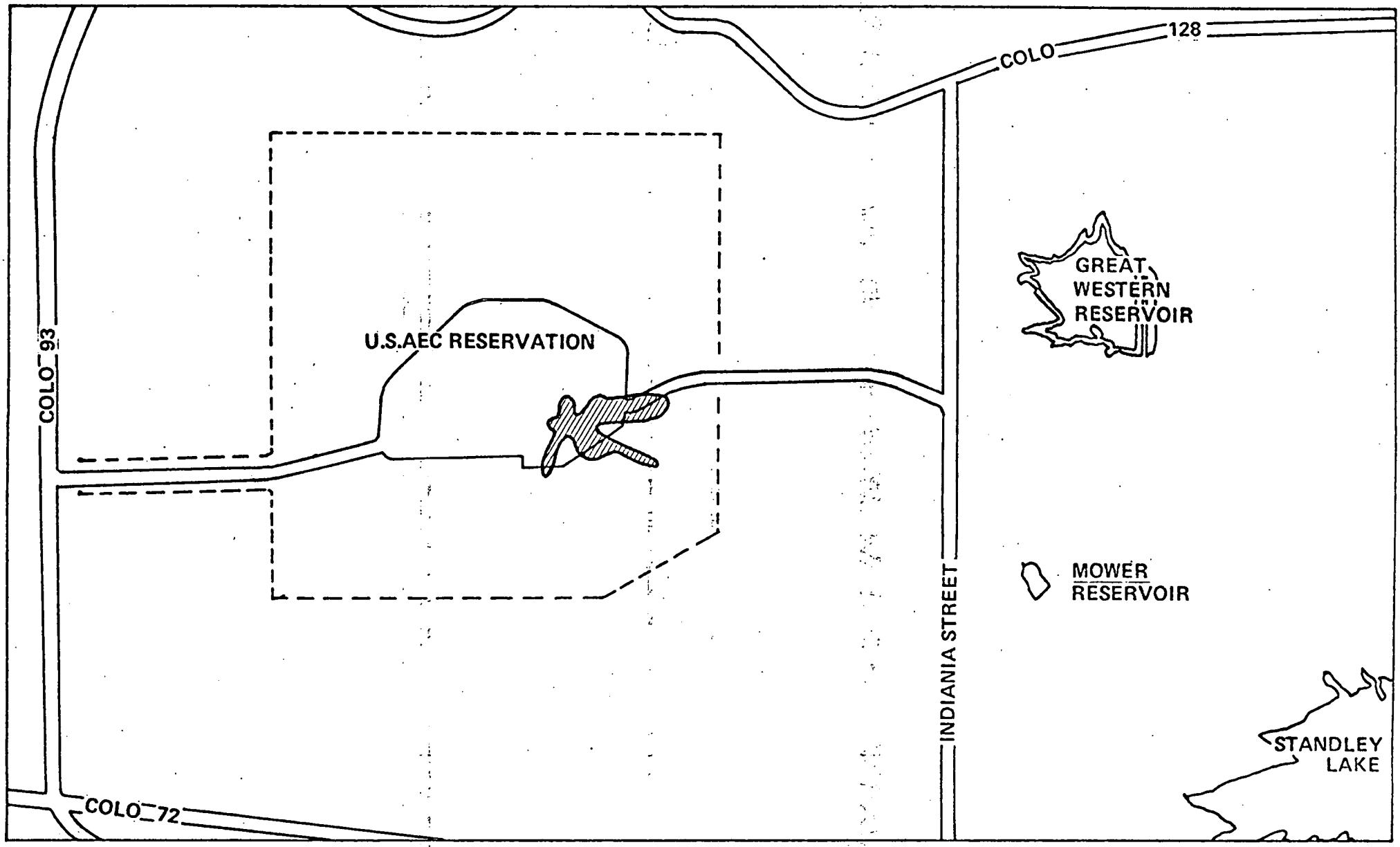
CASE I – MAP II. EXCAVATION OF ALL SOIL GREATER THAN 0.01 $\mu Ci/M^2$ PLUTONIUM.



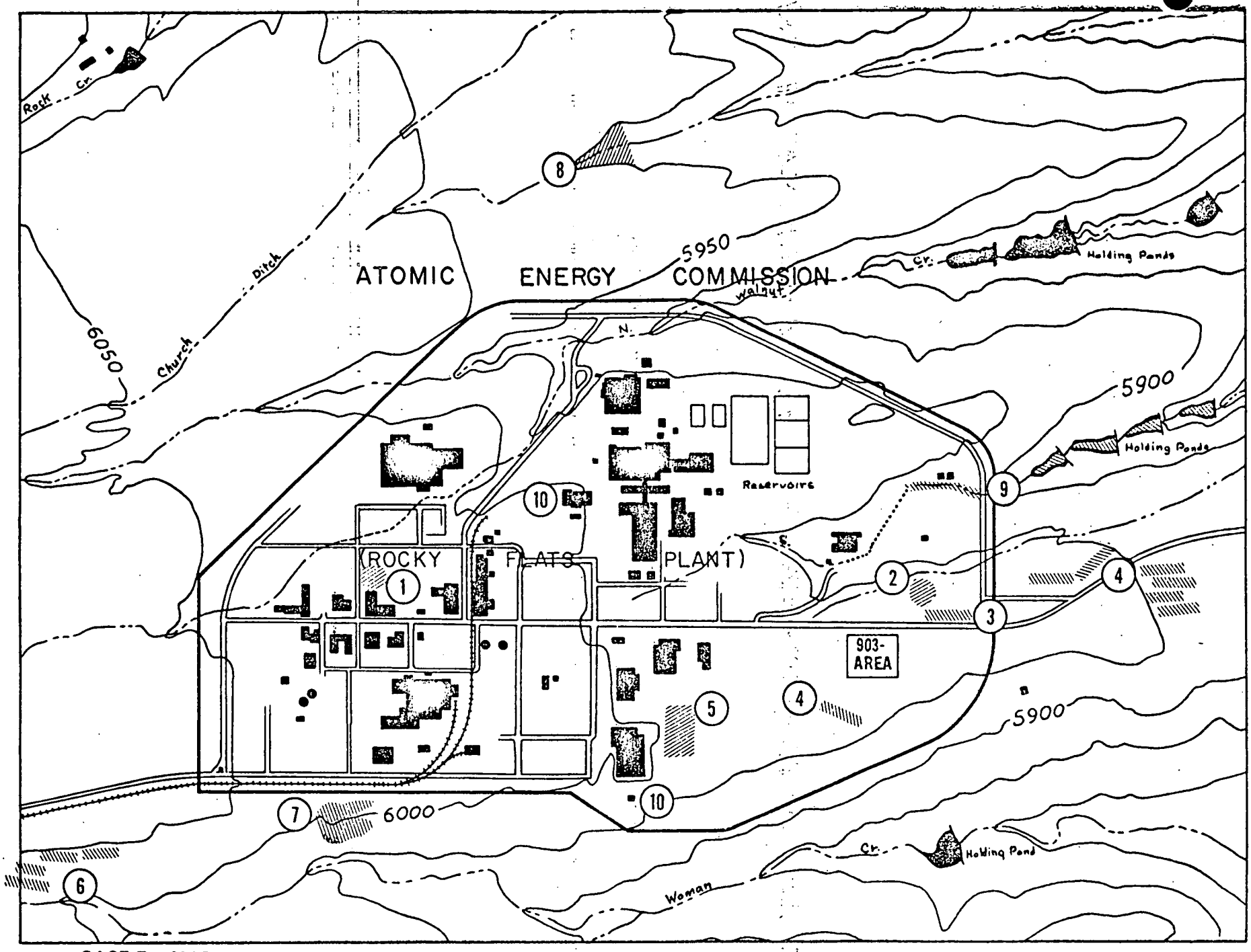
CASE I – MAP III. EXCAVATION OF ALL SOIL GREATER THAN 0.05 $\mu Ci/M^2$ PLUTONIUM.



CASE I – MAP IV. EXCAVATION OF ALL SOIL GREATER THAN 0.5 $\mu Ci/M^2$ PLUTONIUM.



CASE I – MAP V. EXCAVATION OF ALL SOIL GREATER THAN 2.0 $\mu Ci/M^2$ PLUTONIUM.

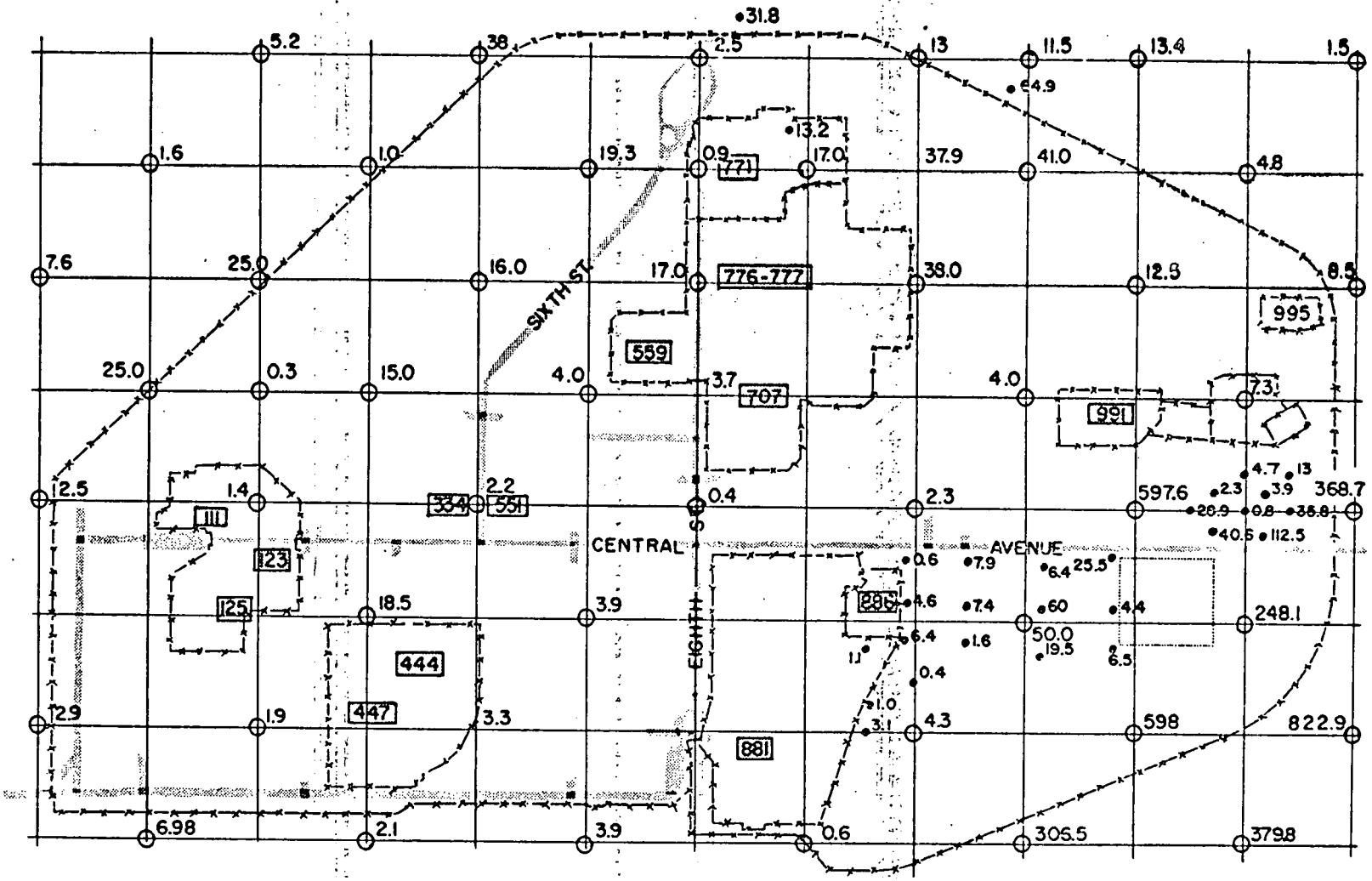

Rock Cr.
Church Ditch
6050
ATOMIC ENERGY COMMISSION
5950
Walnut
N.
Cr.
Holding Ponds
5900
Holding Ponds
Reservoirs
(ROCKY FLATS PLANT)
903-AREA
5900
6000
Cr.
Holding Pond
Woman
1
2
3
4
5
6
7
8
9
10

CASE I – MAP VI

Cases II through VII are based on results of soil samples taken at various locations and for various reasons on the plant site, primarily within the controlled area. These results have been plotted on a grid system which was established by the Austin Company during the original construction of the Rocky Flats Plant. Map 19 presents these results plotted on the Austin Grid System. It must be stressed that in the interest of conservatism the values presented are the maximum level observed within that grid or at a particular sample point. Actual values range from less than the minimum detectable amount to the value presented with as many as six samples in some locations and as few as one sample in others.

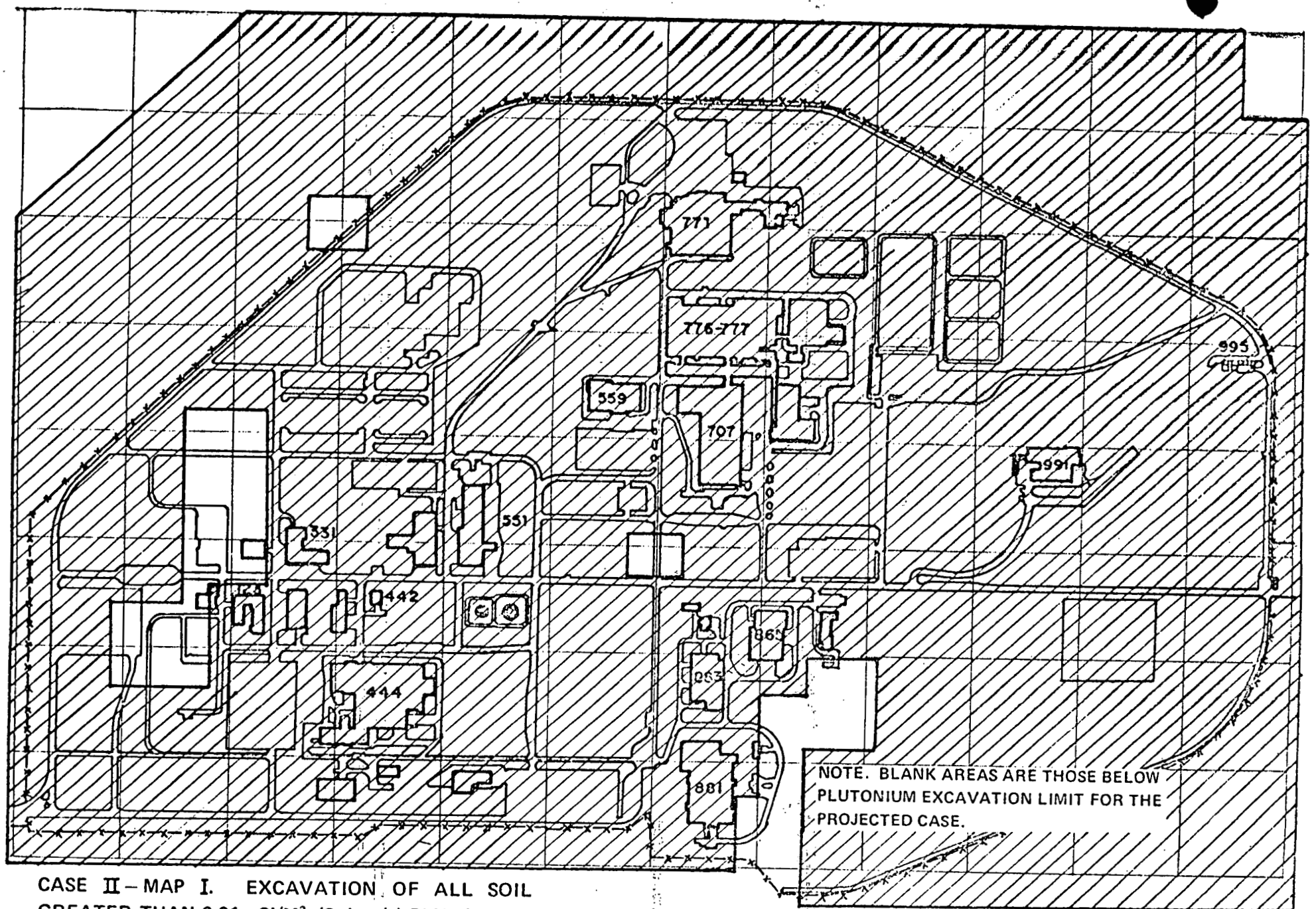
The following maps and Table IV present the estimated volume and area involved for each case. Allowances have been made to exclude space occupied by buildings, to reflect uncertainities by not excluding entire grids where low results seem questionable, and for the special conditions and considerations discussed in Case I-A.

[redacted]

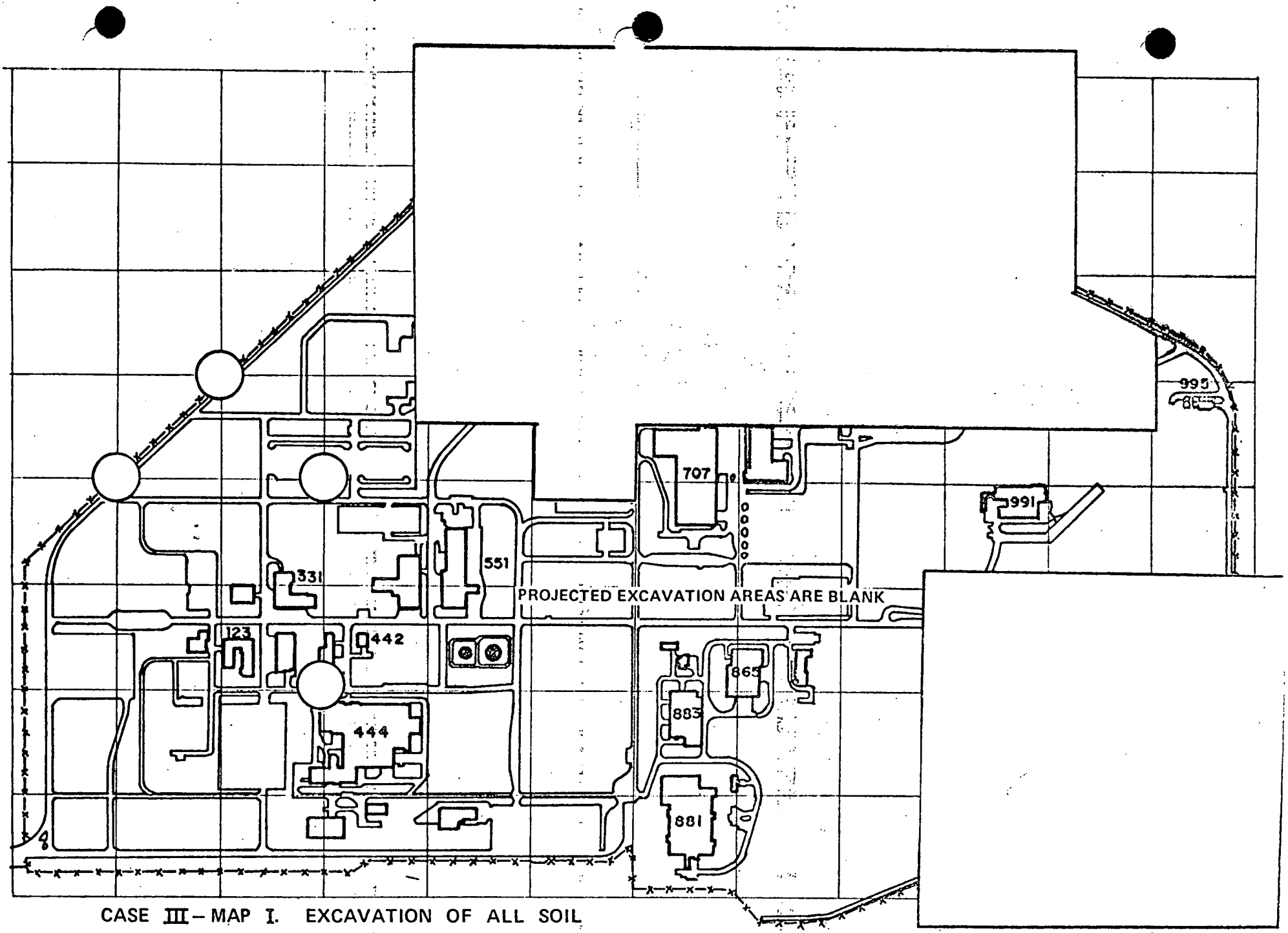


ON-SITE SOIL SAMPLE RESULTS (Pu dpm/g).
ALL INDICATED VALUES=MAXIMUM OBSERVED

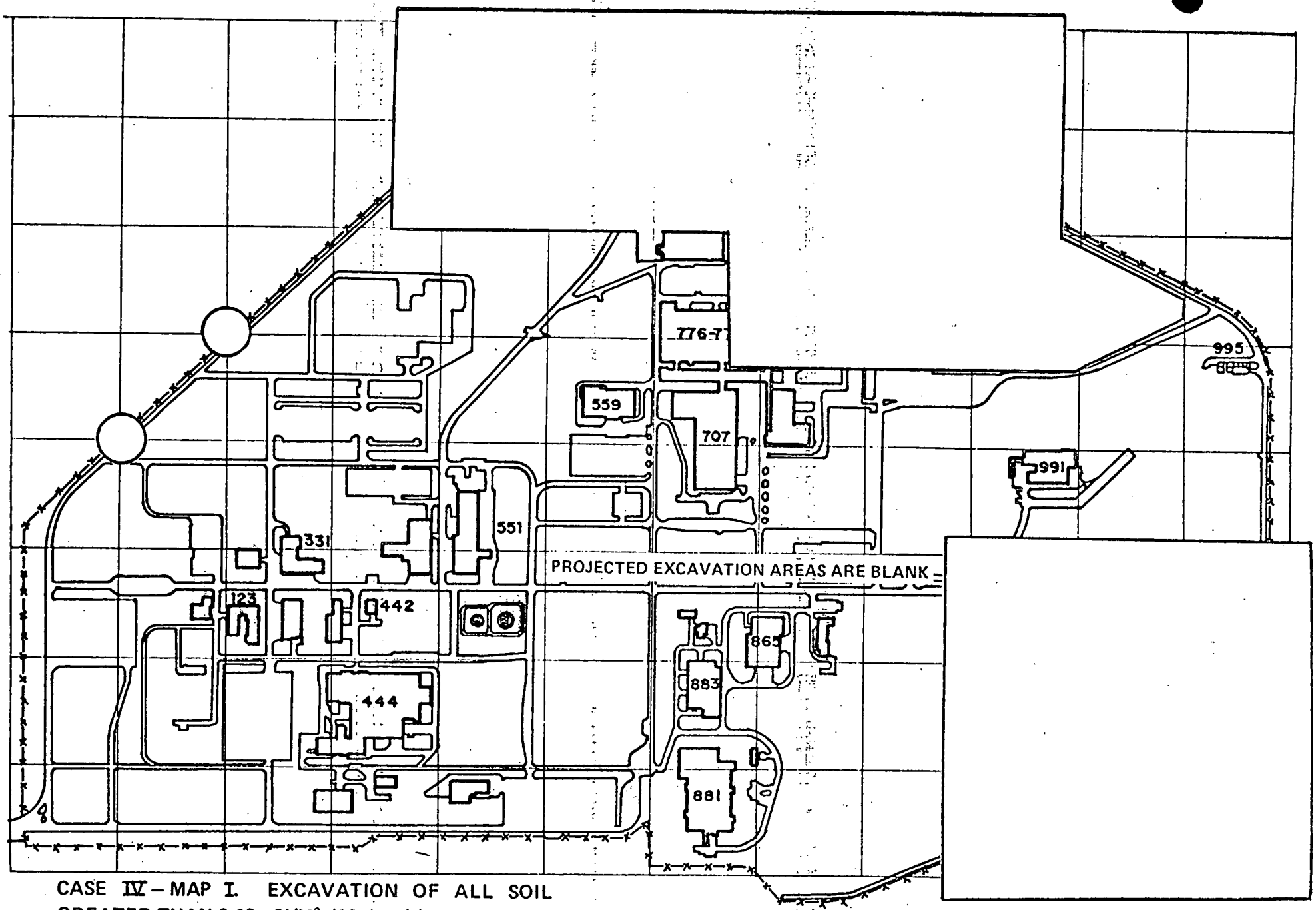
MAP 19.



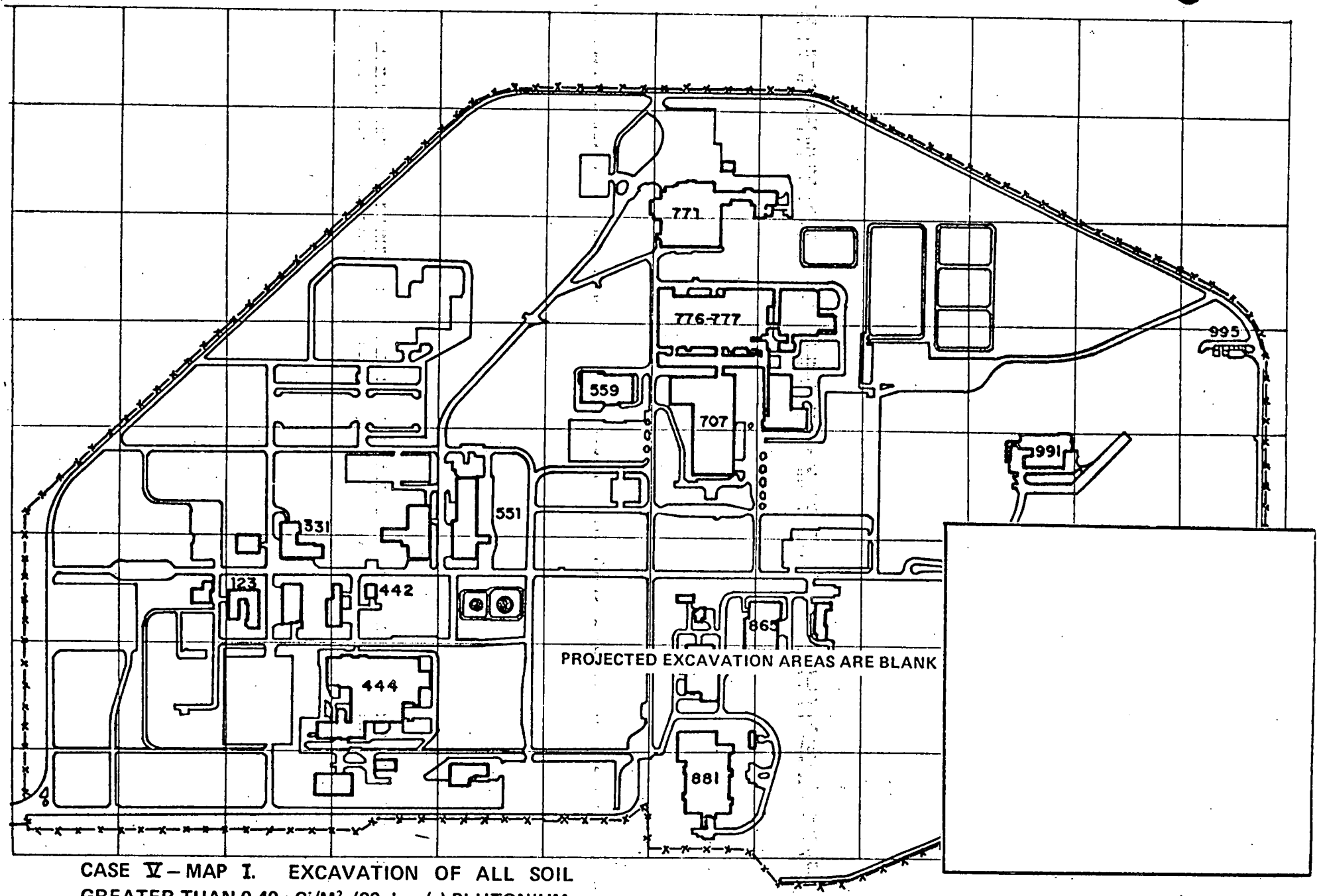
CASE II – MAP I. EXCAVATION OF ALL SOIL GREATER THAN 0.01 $\mu Ci/M^2$ (2 dpm/g) PLUTONIUM.



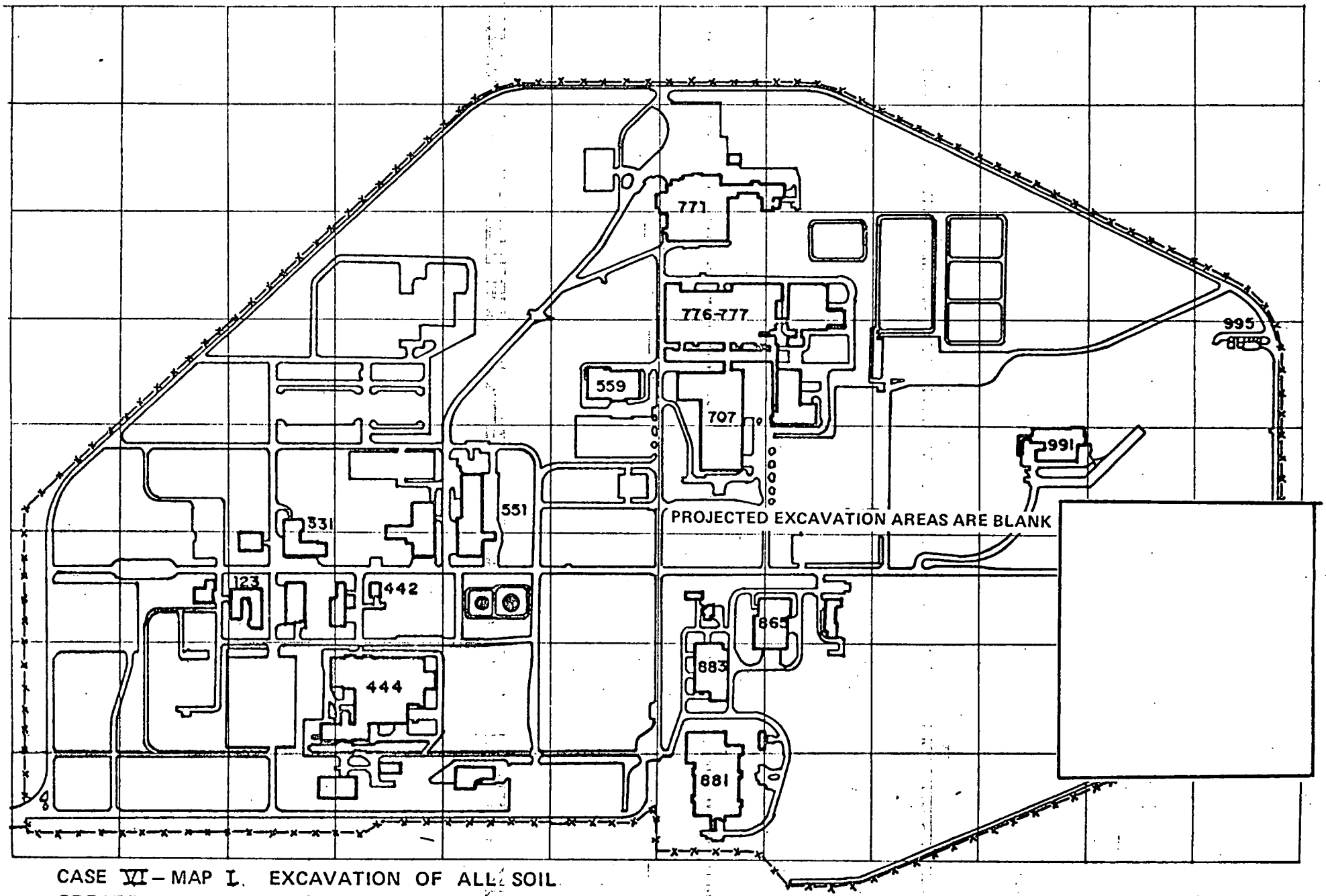
CASE III – MAP I. EXCAVATION OF ALL SOIL GREATER THAN 0.04 $\mu Ci/M^2$ (8 dpm/g) PLUTONIUM.



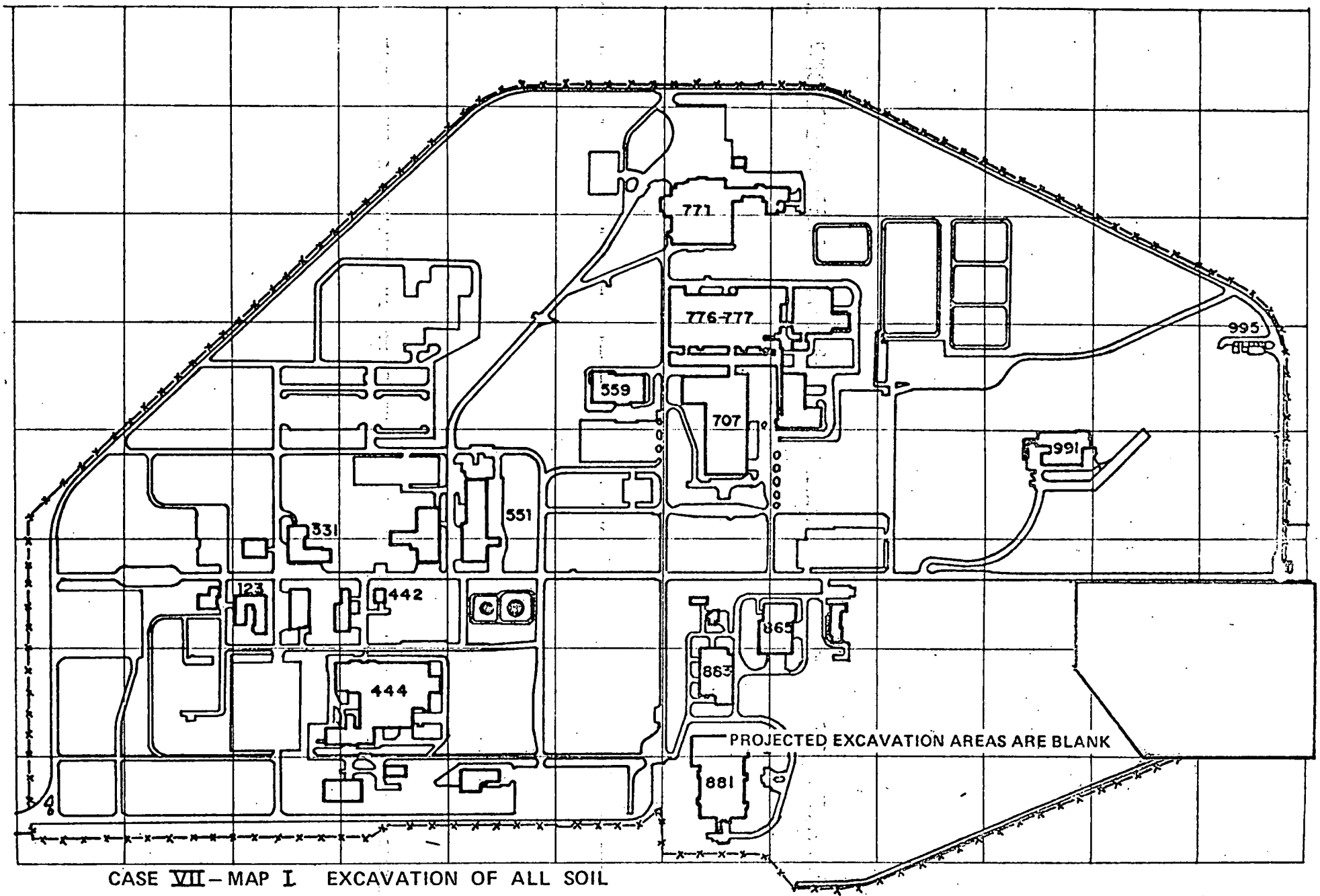
CASE IV – MAP I. EXCAVATION OF ALL SOIL GREATER THAN 0.10 $\mu Ci/M^2$ (20 dpm/g) PLUTONIUM.



CASE V – MAP I. EXCAVATION OF ALL SOIL GREATER THAN 0.40 $\mu Ci/M^2$ (80 dpm/g) PLUTONIUM.



CASE VI – MAP I. EXCAVATION OF ALL SOIL GREATER THAN 2.0 $\mu Ci/M^2$ (400 dpm/g) PLUTONIUM.



CASE VII – MAP I EXCAVATION OF ALL SOIL GREATER THAN 4.0 $\mu Ci/M^2$ (800 dpm/g) PLUTONIUM.

TABLE IV

Estimated Volume to Be Excavated - Cases II through VII
Assuming Removal to Three Inches Below Original Surface

Case	Estimated Square Feet	Estimated Cubic Feet Involved	Allowance For Case I-A Cubic Feet	Estimated Total Cubic Feet Involved
II (2 dpm/g)	16.0×10^6	4.0×10^6	0.5×10^6	4.5×10^6
III (9 dpm/g)	7.4×10^6	1.8×10^6	0.5×10^6	2.3×10^6
IV (22 dpm/g)	5.9×10^6	1.5×10^6	0.5×10^6	2.0×10^6
V (88 dpm/g)	2.6×10^6	0.6×10^6	0.5×10^6	1.1×10^6
VI (440 dpm/g)	1.2×10^6	0.3×10^6	0.4×10^6	0.7×10^6
VII (880 dpm/g)	0.75×10^6	0.19×10^6	0.4×10^6	0.59×10^6

IV. CONCLUSIONS AND RECOMMENDATIONS

Lacking an official definition of "contaminated" makes it impossible to reach sound, logical conclusions or to make recommendations supported by data or policies in usual sense of these words. However, it is possible and necessary to recognize that areas of concern in terms of both radioactive and chemical infiltration do exist at Rocky Flats, if not in terms of risk or hazard at least in terms of political, social, or psychological factors. The following is, therefore, presented for consideration by management in the prudent planning of future operations of the Rocky Flats Plant:

1. Conclusion

There is no data to indicate that any material, either radioactive or chemical, in its present location and status which represents any risk or hazard to man or the environment.

Discussion

Air and water sample results have at various times indicated the presence of radioactive materials and chemicals but have historically been below the concentration guide values set forth in the AEC Manual.

The 903 Area is recognized as having the greatest potential for exceeding the guide values and has been under continual surveillance since 1958 by Rocky Flats Health Physics. During recent years, the State of Colorado, Department of Health, and the U. S. Atomic Energy Commission Health and Safety Laboratory have conducted independent surveillance activities primarily in sampling the air near the area. None of the air samples taken outside of the immediate area of the asphalt pad have exceeded the concentration guide values. Wells located at each corner of the asphalt pad have never indicated the presence of any ground water.

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Sampling of air at other locations both on and off the plant site has produced similar results.

Map 20 indicates the location of wells particularly near process waste holding tanks. The wells are routinely sampled and analyzed for both radioactive materials and chemicals such as plutonium, uranium plus plutonium, nitrates, and pH. With the exception of nitrate concentrations in the vicinity of the 207 solar evaporation ponds, all materials monitored have historically been below the concentration guide values. Installation and operation of the trenches north of the 207 ponds plus the previously discussed repair of these ponds have controlled the nitrate concentration of surface water to within the concentration guide values.

Completion of the new Process Waste Treatment Facility, Building 374, will eliminate the need to use the 207 solar evaporation ponds to contain and evaporate solutions containing large amounts of nitrates and thereby reduce this source of concern starting in 1976.

2. Conclusion

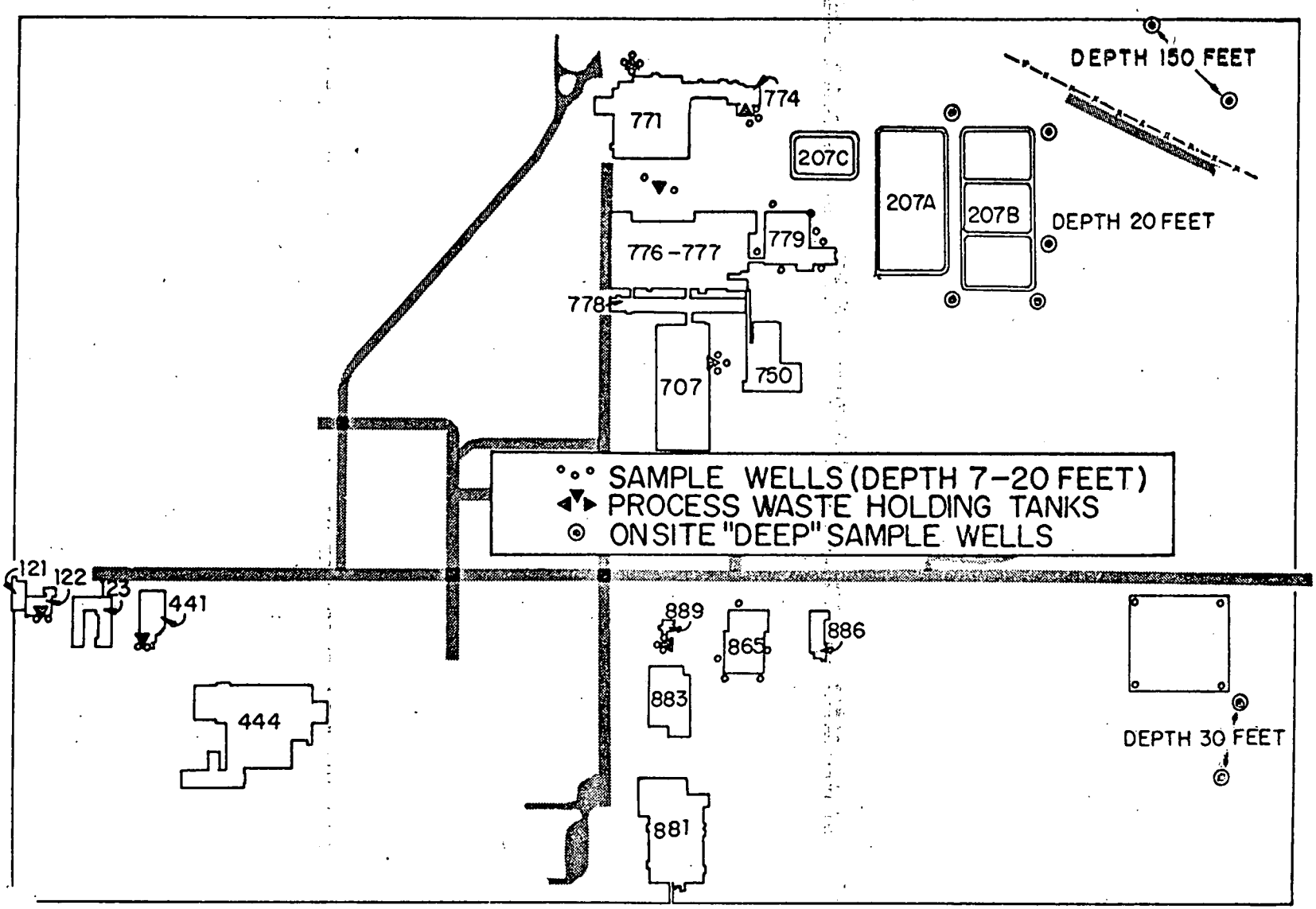
The technology required for proper controlled excavation of any area is unknown.

Discussion

Should excavation of any of the areas discussed be undertaken it would be necessary to provide for the control of airborne materials and to assure that a technique was used which accomplished actual and complete removal, not merely mixing or dilution of the material to less than present minimum detectable amounts or which spread the material to the newly exposed virgin surface. The efficiency or

94

[redacted]


DEPTH 150 FEET
774
771
207C
207A
207B
DEPTH 20 FEET
776-777
779
778
707
750
SAMPLE WELLS (DEPTH 7-20 FEET)
PROCESS WASTE HOLDING TANKS
ONSITE "DEEP" SAMPLE WELLS
121
122
123
441
889
865
886
883
444
DEPTH 30 FEET
881

MAP 20.

degree of effectiveness required of such provisions and techniques would obviously depend upon a decision as to what level of infiltration remaining would be acceptable.

There have been a number of techniques suggested such as separation on the basis of density, washing, or vacuuming, but no data is available to even suggest let alone confirm how efficient these techniques may be.

3. Conclusion

Without a known excavation technique or process it is not possible to estimate capital equipment costs of any excavation. Rocky Flats does have an established and accepted method of determining the cost of disposing of solid radioactive wastes but capital equipment costs are not included.

Discussion

Other sites such as Hanford and the National Reactor Testing Station (NRTS) have estimated capital costs involved in the proposed excavation of locations such as the Z-9 trench at Hanford or the location where until November 1970 Rocky Flats wastes were buried at NRTS. These estimates, $1 million at Hanford and about $10 million at NRTS, are for conditions much different than those areas under consideration in this discussion but they may serve to define the limits of the question.

AEC Manual Chapter 0511, "Radioactive Waste Management," requires that materials known or suspected to contain transuranium nuclides, such as plutonium, in excess of 10 nCi/g (22,000 dpm/g) must be packaged for retrievable storage. It is reasonable to assume that all of the excavation material involved in this discussion would

contain less than 10 nCi of plutonium per gram of soil and could, therefore, be packaged for not readily retrievable storage in the same manner that Rocky Flats now packages non-plutonium wastes, nitrate salts, and domestic sewage sludge for shipment to NRTS. The costs to purchase the packaging materials, warehousing, trucking on-site, monitoring, inspecting, loading for off-site shipment, and freight to NRTS for these types of waste now amount to $6.08/cubic foot in a 55-gallon drum and $2.90/cubic foot in a 4'x4'x7' - 3/4" plywood box. Due to weight restrictions, it is most likely that it would be necessary to reduce the dimensions of the box to 4'x2'x7' which would result in a cost of $5.80/cubic foot. Rounding both of these figures to $6.00/cubic foot and using the estimated volumes from Tables III and IV, estimated disposal costs for each case under discussion not including capital equipment would be as follows:

Case	Estimated Total Cubic Feet Involved	Estimated Cost of Disposal Not Including Capital Equipment (Dollars)
I-A	0.5×10^6	3×10^6
B-1	46.0×10^6	276×10^6
B-2	21.5×10^6	129×10^6
B-3	8.7×10^6	52.2×10^6
B-4	4.0×10^6	24×10^6
B-5	1.2×10^6	7.2×10^6
C-1	70	420
C-2	10,000	60,000
C-3	12,000	72,000
C-4	84,000	504,000
C-5	15,000	90,000
C-6	30,000	180,000
C-7	2.0×10^6	12×10^6
C-8	4.0×10^6	24×10^6
C-9	225,000	1.35×10^6
C-10	2,000	12,000
C-Total	6.4×10^6	38.4×10^6
II	4.5×10^6	27×10^6
III	2.3×10^6	13.8×10^6
IV	2.0×10^6	12×10^6
V	1.1×10^6	6.6×10^6
VI	0.7×10^6	4.2×10^6
VII	0.59×10^6	3.54×10^6

4. Conclusion

Again, without a known excavation technique or process, it is not possible to accurately estimate the rate at which any excavation of any location can be accomplished. However, there are other known factors and estimates which can be used to define some of the limits.

Discussion

Hanford's estimate of the excavation rate for the Z-9 trench is 7.7 cubic feet per shift. Without further elaboration it can be seen that in no way could this rate reasonably satisfy the need should the decision be made to excavate any of the areas included in this discussion.

A factor which is more likely to be limiting and for which there is experience to use as a measure is Rocky Flats ability to load and ship wastes and the ability of NRTS to receive and handle them. Current generation rates at Rocky Flats have required an average of 12 shipments per month for the last six months. These shipments have averaged 1,400 cubic feet per shipment. During the last six months of 1972, Rocky Flats and NRTS demonstrated the ability to handle an average of 22 shipments per month. These shipments averaged about 1,200 cubic feet per shipment. Assuming that the shipping rate for any excavation would be in addition to the current generation and would average 10 shipments per month and 1,200 cubic feet per shipment (12,000 cubic feet per month or 144,000 cubic feet per year) and using the estimated volumes from Tables III and IV estimated time to excavate and ship, each case under discussion would be as follows:

Case	Estimated Total Cubic Feet Involved	Estimated Time Required to Excavate And Ship to NRTS (Years)
I-A	0.5×10^6	3.5
B-1	46.0×10^6	319.4
B-2	21.5×10^6	149.3
B-3	8.7×10^6	60.4
B-4	4.0×10^6	27.8
B-5	1.2×10^6	8.3
C-1	70	
C-2	10,000	0.1
C-3	12,000	0.1
C-4	84,000	0.6
C-5	15,000	0.1
C-6	30,000	0.2
C-7	2.0×10^6	13.9
C-8	4.0×10^6	27.8
C-9	225,000	1.6
C-10	2,000	
C-Total	6.4×10^6	44.4
II	4.5×10^6	31.2
III	2.3×10^6	16.0
IV	2.0×10^6	13.9
V	1.1×10^6	7.6
VI	0.7×10^6	4.9
VII	0.59×10^6	4.1

since the radiotoxicity of these nuclides is of the same order as ^{239}Pu. For some applications (e.g., neutron sources), ^{238}Pu may be the predominant isotope, but generally such applications are few, and the total quantity used is small when compared with that of ^{239}Pu. Furthermore, since the radiotoxicity of the two isotopes is similar, the discussion below generally applies to ^{238}Pu as well.

Because of the high chemical reactivity of plutonium and the probable nature of the accident (viz., giving a rise to a fire), PuO_2 is the assumed chemical form in the environment. This compound is generally considered to be insoluble, and the degree of insolubility is a function of the oxidation temperature.(3) High-fired oxide is most highly insoluble, while oxide produced by auto-oxidation at room temperatures produces the most soluble form of the oxide.

The physical form of the plutonium is assumed to be particulate, with log-normal distribution and a mass median aerodynamic diameter (MMAD) of 1 to 2 μ with σ_g = 1.5 to 2.0. This implies a count mean aerodynamic diameter of 0.5 to 1.0 μ. This particle size distribution, although not the "worst possible case" from an inhalation standpoint, is conservative and has been inferred from experimental studies.(4-7) Stewart,(6,7) for example, in experiments in which metallic plutonium was burned, found that the mass median diameter (MMD) of the airborne fraction of Pu ranged from 0.3 to 29 μ. Similar particle size distributions were reported by Ettinger et. al. (5) and Andersen.(4) Note that the particle size distribution of PuO_2 will vary with ignition temperature; the higher the ignition temperature, the larger the particle size.(7)

ECOLOGY AND FATE OF PLUTONIUM IN THE ENVIRONMENT

Limited data obtained from a series of experiments in Nevada indicate that once deposited, plutonium tends to remain in place on the ground surface.(8) Other data confirm this fact, and indicate that the Pu would remain within the top few inches of soil. The amount of deep leaching into the soil and into the water table would be small, and soil, in fact, acts as a good filtering medium to keep the plutonium out of the ground water. Rain and subsequent runoff, however, might concentrate the plutonium in reservoirs, ponds, lakes, and other bodies of water. If, for example, the Pu is concentrated in puddles which later evaporate, "hot spots" might be created. Data in these areas of concern are not readily available, and generally raise more questions than they answer, including such points as translocation mechanisms, effects of bacterial action, and weathering.

A certain fraction of the plutonium deposited on the ground or other flat surface can be resuspended to give significant air concentrations. A good deal of effort has been devoted to the study of resuspension factors (5-7,9-17), and reported values for plutonium and its compounds range over 11 orders of magnitude!(15) Although some correlation exists among type of surface, wind, and resuspension, the particle size (within limits) and, to a lesser extent, the contamination level seem to make little difference. The plutonium air concentration will vary according to the height above the contaminated surface. Obviously, in enclosed rooms with considerable air circulation, air concentrations will be greater than in rooms with still air or in large open areas.

The resuspension factor (RF), according to at least one study, appears to grow smaller as the material ages.(15) Thus, the air concentrations over

5. Conclusion

Any known excavation technique or process would remove all vegetation and in some areas all of the top soil.

Discussion

It would be necessary to carefully consider and weigh this impact on the environment against any anticipated benefit from excavation of any area. Cost to replace top soil and reestablish the vegetation must be a part of any excavation plan but are not included in the previously presented estimate.

Recommendations

1. The Division of Operational Safety should be encouraged to continue efforts to establish official and accepted concentration guide values for plutonium and other materials in soil.

2. An agreement exists between the U. S. Atomic Energy Commission and the State of Colorado that no actions will be taken to remove the radioactive materials in the 903 Area until such time that a suitable alternate location is established away from Rocky Flats. Under the present conditions and lacking a proven excavation technique, it is likely that excavation of this area at this time presents a greater potential hazard than leaving the area intact. This is also true of the area southeast of the asphalt pad where there is good ground cover with its associated stabilization effect. It is not recommended that excavation of the 903 or any other area be undertaken at this time.

3. It is recommended that the roads on both sides of the security fence east of the 903 Area be seal coated or asphalted from Central Avenue south to approximately Austin Grid E-22,500 or that traffic be restricted to only that which is essential to environmental sampling, security patrols, and fire watch activities.

In summary, it is not recommended that excavation of any area be undertaken at this time. We will continue current preventative actions, maintain and improve the current surveillance and monitoring programs, continue to study and thereby improve our understanding of the existing conditions, and develop techniques and management programs should excavation of any area be deemed desirable or necessary in the future.

BNWL-SA-1510

TOWARDS INTERIM ACCEPTABLE SURFACE CONTAMINATION LEVELS FOR ENVIRONMENTAL PuO_2 *

5.9

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INTRODUCTION

Metallic ^{239}Pu is being used in increasing quantities for reactor fuels and for nuclear warheads. Although the probability is quite small, an appreciable amount of plutonium could be involved in a fire, explosion, or other incident causing contamination of the surrounding area. An incident of this type occurred near Palomares, Spain, in January 1966, when two U.S. Air Force planes collided in midair. Two plutonium-bearing weapons contaminated a significant area of the countryside, and rather extensive decontamination efforts were employed over a portion of the area.(1) The cost of this operation has been estimated at 50 million dollars, of which only about 5 million dollars was expended in recovery of the weapon lost in the sea. A second incident, quite similar to the one at Palomares, occurred early this year. At the time of this writing, specific data regarding the extent of environmental contamination are not available.

The probability of a serious accident has been computed for several modes of shipment, based on available information (U.S.A.) of accident frequency and severity.(2) For certified all-cargo commercial aircraft, this probability is 1/42,000 per 1,000 miles traveled. For other modes of commercial shipment, the probability of a serious accident per 1,000 miles is a factor of 2 to 4 less.

Evaluation of the degree of hazard resulting from such an accident is not an easy task, because few data apply directly to a specific field situation. Many factors need to be considered, and where data are lacking, reasonable yet conservative assumptions should be made.

This report will consider briefly the physical and biological factors pertinent to the establishment of acceptable surface contamination levels for environmental $^{239}PuO_2$. The practical difficulty of actual field measurement of these levels will be omitted, as will discussion of the economic, social, psychological, moral, and other intangible factors. Presented below is a brief analysis of the surface contamination hazard from a serious accident involving release of ^{239}Pu. Rather than provide a complete literature survey, an overview has been made with pertinent references cited.

CHEMICAL AND PHYSICAL FORM

For the practical purposes of hazard evaluation, plutonium metal might be considered as composed wholly of the fissile isotope 239. Although small amounts of $^{240-242}Pu$ and ^{241}Am may be present along with other radioactive impurities, these nuclides do not appreciably alter the hazards evaluation,

* This paper is based on work performed under United States Atomic Energy

a contaminated surface will be reduced with time. This "air concentration half life" ranges from 30 to 60 days,(15,16) and 45 days was selected as a reasonable value. Reduction of airborne plutonium is a result of weathering, translocation, and other conditions which bind the Pu to the ground. Weathering is probably the most important single factor affecting the airborne Pu levels.

Review of the available pertinent literature would indicate that a RF of 10^{-4} M^{-1}, although conservative, is appropriate. In support of this value the data of Stewart(17) is particularly germane. For deposition from a series of weapons experiments with both plutonium and uranium, resuspension factors as great as 7×10^{-4} M^{-1} were seen. For outdoor conditions with moderate activity, Stewart proposes a value of 10^{-5} to 10^{-4} M^{-1} as a guideline. For quiescent outdoor conditions, 10^{-6} M^{-1} is suggested.

Working with PuO_2, Jones and Pond(14) found an average RF of 5×10^{-5} M^{-1} in a laboratory with a person moving across the floor at the rate of 36 steps per minute. In enclosed rooms with considerable movement, RF's of 10^{-4} to $>10^{-3}$ M^{-1} have been reported.(10,12) These latter situations are somewhat analogous to a house into which contamination has been tracked from the outside, and in which the occupants are carrying on normal living activities.

Other confirmatory data can be obtained from industrial experience with uranium.(9) However, the data are not always applicable to the widespread environmental case. Much of the available environmental data, notably the Plumbbob results,(8,11,16,17) are questionable when carefully scrutinized. The absence of adequate data strongly justifies selection of a conservative RF, and 10^{-4} M^{-1} appears satisfactory at this time.

The ecology of environmental PuO_2 is of singular importance, yet there is a paucity of pertinent data relating to plutonium in man's food chain. The few studies of plutonium uptake by plants growing in contaminated soil (16,18-20) indicate that the uptake by the leaves is quite small. Even when $Pu(NO_3)$, which is more soluble than PuO_2, was used, the concentration in plant leaves was only about 0.01% that of the concentration in the soil. The concentration in the roots were much greater. Data are available for barley, beans, and peas;(18-20) however, no data are given for root crops (e.g., carrots) or perennials.

Concentration of Pu in the tissues of animals used for food is not to be expected. Gastro-intestinal absorption of Pu is small(21-22), and in the event of uptake, most of the plutonium would deposit in inedible portions of the animal, such as the bone, or in the liver. When these factors are combined with the small amount of plutonium expected in plant foods eaten by the animals, this potential source or reservoir of plutonium is negligible, at least when considering the hazard to man.

THE NATURE OF THE HAZARD

Contamination of the environment by PuO_2 would primarily present an internal radiation hazard to the populace. Of the three basic routes of entry, the percutaneous would seem to be the least hazardous unless a fairly large amount of contaminant were introduced through the broken skin.(24) Percutaneous absorption through the unbroken skin and skin exposure are negligible, although a few particles of PuO_2 in a wound might cause problems. This latter case would be exceptional however. Entry by the ingestion route

is far less likely to create a hazard(24,26) because the fractional uptake from the human gut is only 0.003%(21) for ingested Pu. Hence, even if the Pu were concentrated in foodstuffs, the uptake from ingestion would be small. And, only with millicurie/day intakes would the dose to the G.I. tract be sufficiently great to cause concern.

The inhalation hazard of PuO_2 greatly exceeds the ingestion or percutaneous hazard and is the limiting factor. This is partly attributable to the small mass of the pulmonary lymph nodes, 20 gm,(27,28) and the fraction of inhaled dust retained in them.(29-34) This fraction is about 2% for PuO_2 particles of the type specified earlier.(29) (Certain questions, of course, remain unanswered: e.g., How much Pu crosses the placenta and is incorporated into the fetus? Questions of this nature, however, refer to rather specific cases and can only be resolved by further experimental work beyond the scope of this evaluation). Using the International Committee on Radiological Protection task group model for lung clearance,(29) the lymph nodes will be the critical organ, primarily because of their small mass and the essentially infinite (from a biological point of view) effective half-life of the PuO_2 particles deposited in them.

It is difficult to assess, or even to compute, a permissible level of exposure. Biological parameters are defined by Standard Man data, and the 1965 ICRP Recommendations(29) also provide an indication of acceptable risk. The ICRP promulgates a Dose Limit of 1.5 rem/yr to the lungs of a population group exposed to controllable sources. For disaster type situations or emergencies, the only guideline given is essentially "judicious decision making." In general, the Committee, as well as this inquiry, advocates an actual dose as near zero as possible. However, for a population group in a plutonium contaminated environment, a limiting lung dose of 1.5 rem/yr may well be acceptable. Although desirable, it may not be practicable to reduce area contamination levels to zero following a release; therefore, acceptable levels for environmental PuO_2 have been calculated, based on the following premises:

1) Decontamination efforts to reduce surface contamination below these levels are not feasible.
2) PuO_2 or other insoluble α emitters of similar hazard are the primary source of contamination.
3) An acceptable risk is 1.5 rem/yr to the adult pulmonary lymph nodes.(29)
4) Technical data:

Particle Size: 2 μ MMD
$\sigma_g \sim 1.5$

20% deposition in pulmonary compartment, with 15% of this quantity transferred to the pulmonary lymph nodes.(29)

Mass of pulmonary lymph nodes = 20 g.(27,28)

T_{EFF} in pulmonary lymph nodes = ∞ for 90% particles; and 360 days for remainder.(29)

Ground to air resuspension factor: $\sim 10^{-4}$ M^{-1}.

Air concentration half life = $\sim$ 45 days.(11)

Pulmonary compartment to lymph node transfer half life = 360 days.(29)

$$f_p = 0.25$$
$$f_x = 0.15$$
$$\lambda_x = \frac{0.693}{360} = 2 \times 10^{-3}/\text{day}$$
$$f_L = 0.1$$
$$\lambda_L = \frac{0.693}{360} = 2 \times 10^{-3}/\text{day}$$

If t, the time in the contaminated area, is taken as 50 years, and the integral solved for C_o, the following values are obtained:

$$C_o \approx 0.04 \ \mu Ci/m^2$$
$$\approx 0.7 \ g/m^2$$
$$\approx 10^3 \ \text{dis/min per 100 cm}^2$$

The value chosen for the superior limit of the integral is not critical because almost the entire lung burden will be accumulated within the first six months. The levels cited above would apply to an urban area fairly uniformly contaminated with plutonium. Other factors will affect the permissible levels of plutonium contamination, including the land area involved, the land use, and the population density. Lower levels are indicated within a densely populated urban area as opposed to open rangeland or desert, since more people will be exposed, thereby increasing the number of persons who may be adversely affected. The population characteristics are also important, for infants and children or other classes of people might be more susceptible to adverse effects. However, data are lacking in this area of interest, and so only the general case was considered.

Land use considerations were made subjectively, and the following interim maximum permissible surface contamination levels were derived for four land use categories.

The levels cited in Table I are based primarily on inhalation hazard, not ingestion. In the case of farming operations, possible concentration by edible root crops (e.g., carrots, turnips) or by food animals and in milk was considered. However, the need for further study of the ecology of environmental plutonium cannot be too strongly emphasized. Note that the levels cited appear satisfactory for children also, partly because the long equilibration time and smaller breathing volume offset the reduced mass of the pulmonary lung nodes and the possible increase in radiosensitivity.

TABLE I. Interim Maximum Permissible Surface Contamination Levels for Environmental PuO_2

Urban, suburban, and recreation areas	Average: 10^3 dis/min per 100 cm^2 ($0.04 \ \mu Ci/m^2$) Maximum: 10^4 dis/min per 100 cm^2 ($0.7 \ \mu Ci/m^2$), spread over $\leq 10\%$ of the total area included
Rural: truck farming, annual food crops, grazing land, milkshed, etc.	Average: 10^4 dis/min per 100 cm^2 ($0.4 \ \mu Ci/m^2$)
Rural: deep root perennials (e.g. nuts, certain fruits)	Average: 10^5 dis/min per 100 cm^2 ($4 \ \mu Ci/m^2$)

Thus, approximately 3.2×10^{-5} μCi in the adult pulmonary lymph will produce a dose of 1.5 rem/yr, as indicated by the calculation below:

The quantity, q, of ^{239}Pu (in μCi) in the pulmonary lymph nodes that will provide a dose rate, $\frac{d\ rem}{dt}$, of 1.7×10^{-4} rem/hr (= 1.5 rem/yr) can be computed by

$$\frac{d\ rem}{dt} = \frac{k_1\ k_2\ q\ \Sigma EF(RBE)n}{k_3 m}$$

in which k_1 is a constant equal to 1.33×10^8 dis/hr/ μCi,
k_2 is a constant equal to 1.6×10^{-6} ergs/MeV,
k_3 is a constant equal to 100 erg/g/rad,
$\Sigma EF(RBE)n$ is the effective absorbed energy in MeV-rem/dis-rad,
and m is the mass of the pulmonary lymph nodes, in grams.

Putting in the values for the constants, and solving for q,

$$q = \frac{100 \times 20 \times 1.7 \times 10^{-4}}{1.33 \times 10^8 \times 1.6 \times 10^{-6} \times 53} = 3.2 \times 10^{-5}\ \mu Ci.$$

This quantity can be related to an initial ground contamination level, C_o, by the equation

$$q = \int_o^t C_o\ (RF)\ e^{-\lambda_c t}\ J\ f_p\ f_x\ (1 - e^{-\lambda_x t}) - f_L\ (\text{previous term})\ e^{-\lambda_L t}\ dt$$

$$= \int_o^t C_o\ (RF)\ e^{-\lambda_c t}\ J\ f_p\ f_x\ (1 - e^{-\lambda_x t})(1 - f_L e^{-\lambda_L t})\ dt.$$

In this equation, the terms are defined as shown:

C_o is the initial ground concentration, in $\mu Ci/m^2$.

RF is the resuspension factor.

λ_c is the air concentration reduction factor, in $days^{-1}$, which is equal to $\frac{0.693}{45} = 0.014$. The 45-day quantity refers to the air concentration half-life; see supra.

J is the breathing rate, taken as 20 m^3/day.

f_x is the fraction transferred from the pulmonary compartment to the pulmonary lymph nodes.

f_p is the fraction of inhaled particles deposited in the pulmonary compartment.

λ_x is the clearance constant for f_x.

f_L is the fraction cleared from the pulmonary lymph nodes, and

λ_L is the clearance constant for f_L.

For any given particle distribution, the constants f_p, f_x, λ_x, f_L, and λ_L can be obtained from the ICRP Task Group data.(29) For PuO_2 with the particle distribution assumed above, the appropiate values are:

Remote or Controlled: desert, forest, fenced or limited access areas. — Average: 10^6 dis/min per 100 cm^2 (4 $\mu Ci/m^2$)

COMPARISON WITH OTHER STANDARDS

The literature abounds with suggested maximum surface contamination levels, some of which have been written into law and are tabulated in Table II. With the exception of the U.S.S.R., which is far more restrictive, all are within reasonable agreement with the most restrictive level cited in Table I. However, these levels refer to the industrial or work situation, and hence, are not strictly comparable with environmental levels. Dunster, (38-41) who has extensively studied contamination hazards, advocates 10^{-5} $\mu Ci/cm^2$ (2200 dis/min per 100 cm^2) for widespread areas contaminated with plutonium, and his work essentially stands alone.

TABLE II. Summary of International Permissible Alpha Contamination Levels Written into Law.

Country	Maximum Permissible Alpha Contamination ($\mu Ci/m^2$)	Application	Reference
Czechoslavakia	0.11	Workplaces, after decontamination	35
France	0.01	Skin	36
	0.1	Equipment and workplaces in "inactive" areas	
	1.0	Equipment and workplaces in "active" areas	
Poland	0.1	Laboratories restricted to 100 μCi	35, 36
	1.0	Laboratories in which 100 μCi permitted	
South Africa	0.1	Body, personal clothing, inactive areas, etc.	35
	1.0	Equipment and workplaces inside controlled areas	

TABLE II. (contd)

Country	Maximum Permissible Alpha Contamination ($\mu Ci/m^2$)	Application	Reference
United States	0.02	Interstate Commerce Commission (Department of Transportation), pertains to interior of vehicles previously used for transportation of radioactive materials	37
U.S.S.R.	0.015	Work Clothing and surfaces before cleaning	35
	0.002	Hands and work underclothing, before cleaning	
	0.006	Work surfaces, after cleaning	
	Background	Hands and work underclothing, after cleaning	
United Kingdom	0.1	"Inactive" areas	36
	1.0	"Active" areas	

Generally, suggested or required maximum permissible surface contamination levels for both work and non-work environments agree with those cited in Table II or by Dunster. However, there is one notable exception: the U.S. Department of Defense. The level of 62 $\mu Ci/m^2$ (1.34×10^6 dis/min per 100 cm^2) has been promulgated by the U.S. Air Force.(48) This level is two to three orders of magnitude greater than contemporary health physics practice,(43-46) and about 4 orders of magnitude higher than those suggested by Dunster.(38-41) The Navy publication PORRAC, without regulatory status, indicates a final clearance level acceptable for unrestricted release as about 0.04 $\mu Ci/m^2$ (800 dis/min per 100 cm^2).(47) However, another Navy publication has suggested an alpha contamination level of 0.62 $\mu Ci/m^2$ (1.34×10^4 dis/min per 100 cm^2) has been suggested for shipboard occupancy on a continuous basis.(48-49)

Although such a discussion could be carried on at considerable length (perhaps ad infinitum!), the point has been made: considerable confusion exists with respect to alpha contamination limits in the environment. Existing standards are based upon woefully inadaquate data; often a conservative approach is not utilized. More information is needed, especially regarding the fate of plutonium (and other alpha emitters) in the environment. Until such information becomes available, the interim standards of Table I are put forth as consistent with good health physics practice.

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